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The association between occupational hazard exposures and health inequality among Korean employees

한국 임금노동자에서의 직업적 위해요인 노출과 건강 불평등의 관련성에 관한 연구

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Abstract

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Introduction

From birth to retirement, living conditions substancially influence health. Unfair social relationships have created a social environment in which persons with low socioeconomic status (SES) could be exposed to more harmful living conditions. Working conditions and employment status significally affect health in the economically active ages. Joining in the labor market can have a positive impact on health; conversely, working might mean more exposure to harmful working conditions. Work is the main source of income for most people. Occupations have linkages to social status; people's self-esteem could be affected by their jobs and the workplace is an important place for making social relationships in adulthood. On the other hand, work is associated with various exposures which can be harmful to health. Employees could be exposed to physical, chemical,

ergonomic, and psycho-social hazards by joining the labor market, and workers in low socioeconomic status have a higher tendency to work in harmful working conditions. These unequal exposures to occupational risk factors among different occupations could be an important pathway to understanding health inequality. Since the publication of the Whitehall Study II, the majority of studies investigated health inequalities linked with psychosocial risk factors in the workplace. Health inequality can be explained by different levels of exposures to psychosocial factors including low job control, job strain, effort-reward imbalance, organizational injustice. The link between psychosocial working conditions and health inequality has been extensively studied in European countries. The interest in psychosocial working conditions reflected the social circumstances of post-industrialized society. The decrease in the numbers of workers in traditional industries such as manufacturing decreased the number of workers exposed to traditional occupational hazards such as noise and ergonomic strains. However, according to surveys on working conditions in both Korea and EU countries, significant proportions of workers are exposed to traditional occupational hazards and are working in dangerous working circumstances which are prone to industrial accidents and toxic exposure. Furthermore, in Korea industrial accidents and intoxications are much more frequent than in European countries due to the improper implementation of

safety and health regulations at the workplace. Several studies of European countries investigated health inequalities which are related to occupational hazard exposures including physical, chemical, and ergonomic risk factors. Yet, health inequality related to physical, chemical, and ergonomic occupational hazard exposures have been insufficiently explored, particularly in Korea. Considering the situation mentioned above, broad working conditions, including workplace safety as well as physical, chemical, biological, ergonomic, and psychosocial hazards, need to be investigated as factors generating health inequality, particularly in working ages.

Chapter 1

Objectives: The purpose of the chapter was to assess exposure to occupational hazards across different occupations and the contribution of occupational exposures to poor self-rated health (SRH) and work-related injury.

Methods: Employees from the sample of the Third Korean Working Conditions Survey (KWCS) were the study population. Survey weighted chi-square tests and multiple survey logistic analyses were undertaken for statistical analysis. A DAG (Directed Acyclic Diagram) was employed to identify the minimal sufficient adjustment set.

Results: For most occupational hazards, the gradient of exposures were observed. Higher proportions of employees in a low SES were exposed to occupational hazards. Occupatinal hazard exposures incresed the risk of poor self-rated health and work-related injury.

Conclusions: Occupational hazard exposure could be linked to health inequality among Korean employees.

Chapter 2

Objectives: The purpose of the chapter was to decompose the health gap between manual workers and non-manual workers into direct effect (the effect of SES per se) and indirect effect (the effect of mediators) by undertaking the mediation analysis.

Methods: The author used employee data from the Third Korean Working Conditions Survey (KWCS) as the population. Mediators were perceived risk, low job control, long working hours, low income, and financial imbalance. For the mediation analysis, user-made commands “paramed” and “medeff” were utilized in Stata Program.

Results:The proportion of effect mediated by perceived risk at work was 39% (95%CI: 28-65%). The proportion of effect mediated by financial imbalance was 22% (95%CI:16%-39%). The proportion of effect mediated by low job control

was 7% (95%CI:5%-13%). The proportion of effect mediated by less than median income was 5% (95%CI:3%-9%). The proportion of effect mediated by unstable employment was 20% (95%CI:15%-34%).The proportion of effect mediated by long working hours was 28% (95%CI: 20%-47%).

Conclusions: Perceived risk at work and long working hours might contribute to a health gap between non-manual workers and manual workers with greater magnitude than other mediators.

Chapter 3

Objectives: The purpose of the chapter was to investigate the simultaneous effect of exposure to perceived risk and unstable employment on self-rated health in both Korean and the EU.

Methods: The author carried out analyses using the employee data from the Third Korean Working Conditions Survey (KWCS) and Fifth European Working condition survey (EWCS). Survey logistic analysis and post-estimation commands were employed for interaction analysis. Interaction analyses was undertaken by both additive scale (Relative Excess of Risk due to interaction) and multiplicative scale (The Ratios of Odds Ratios).

Results: The odds ratio (OR) of poor self-rated health was 2.00 (95% confidence interval [CI]: 1.80–2.22) for perceived risk at work, 1.18 (95% CI:

1.09–1.28) for unstable employment, and 3.22 (95% CI: 2.72–3.81) for both for perceived risk at work and unstable employment. The RERI was 1.03 (95% CI: 0.48–1.58) among Korean employees. The odds ratio (OR) for poor self-rated health was 3.20 (95%CI: 2.93–3.49) for perceived risk at work, 1.04 (95% CI: 0.97–1.13) for unstable employment, and 3.41 (95% CI: 2.93–3.98) for both for perceived risk at work and unstable employment. The RERI was 0.18 (95% CI: -0.36–0.71) among European employees.

Conclusions: Among Korea employees a supra-additive interaction between perceived risk at work and unstable employment on poor self-rated health was observed. However, among European employees a supra-additive interaction was not observed.

Chapter 4 (This Chapter was accepted and will be published in JOEM)

Objectives: The aim of the chapter was to investigate the combined effects of long working hours and low job control on self-rated health.

Methods: Employees from the Third Korean Working Conditions Survey (KWCS) were the study population. Survey logistic analysis was conducted and then post-estimation commands were employed to estimate the relative excess risk due to interaction (RERI).

Results: The odds ratio (OR) for poor self-rated health was 1.24 (95%

confidence interval [CI]: 1.13–1.35) for long working hours, 1.04 (95% CI: 0.97–1.13) for low job control, and 1.47(95% CI: 1.33–1.62) for both long working hours and low job control. The RERI was 0.18 (95% CI: 0.02–0.34).

Conclusions: These results imply that low job control may increase the negative influence of long working hours on self-rated health.

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The author would like to express appreciation to Korea Occupational Safety and Health Agency (KOSHA) for providing the raw data of the third Korean Working Condition Survey.

Keywords: health, inequality, occupational exposures

Student Number: 2010-31232

Table of contents

Introduction of thesis

Chapter 1. Occupational hazard exposures by occupation and employment status among Korean employees.

Chapter 2. The decomposition of the health gap between manual and non-manual employees by mediation analyses

Introduction of thesis

Definition and concept of health inequality

The Dictionary of Epidemiology (6th Edition) defined health inequality and health inequity as follows: “Differences in health status or in the distribution of health determinants between different population groups. Some are attributable to biological variations or free choice, and others to the external environment and social conditions outside the control of individuals. In the latter case, they may be unnecessary and avoidable as well as unjust and unfair, and cause or reflect health inequity”.(1) Also,health equity was defined as follows:“Equity in health implies that ideally everyone should have a fair opportunity to attain their full health potential and, more pragmatically, that no one should be disadvantaged from achieving this potential, if it can be avoided”.(2) In summary, health inequalities mean that differences in health status result from unfair social structures or relationships. However, the meaning of avoidability and fairness may vary and depend on technological capabilities and social environments.

Life course approach to health inequality.

Throughout a person’s life, daily living conditions greatly influence health. Unequal social structures and relationships have created a social environment

in which people with low socioeconomic status can potentially be exposed to more harmful living conditions. Through the life course, people with a lower socioeconomic position can be exposed to various health hazards which can be a crucial pathway to health inequality.(3)

Fetal and early life could influence health of later life. This linkage is observed not only in epidemiologic studiesbut also in cellular and molecular studies. The study explored the biologic mechanism of the relation between early life exposures andhealth later in life.(4) Educational levels also influence health via social positions and different health behaviors including alcohol consumption and smoking. As seen in the Black report, Socioeconomic status (SES) of adulthood including occupational class significantly affects health.(5) This influence might extend to the age of retirement.(6)

Pathway and explanation of health inequality

The Black Report could be the first study which systematically investigated health inequality in the national level. “Black report” suggested that artifact, Social selection, and material, cultural and behavioral factors could be possible pathways of health inequalities.(5)The Whitehall Study II demonstrated psychosocial factors at the workplace, including low job control and effort-reward imbalance, can contribute the health inequality(7, 8). Other studies

argued that political and macro-economic environments could influence health inequality.(9)

Occupation or occupational class as the measurement of socioeconomic Status (SES)

Much research, including the Black Report on health inequality, used occupational class or occupations as indicators of SES. The Black Report used RGSC as the measurement of SES. In RGSC, occupational class is classified by “occupational skill” and “general standing in the society.” The concept of “general standing in the society” and “occupational skills” are based on Weber’s social theory.(10) Similar to RGSC, the questionnaire of the Third Korean Working Condition Survey used a similar classification in defining the occupational classes of RGSC. Occupations were categorized by subjective assessment in the Third Korean Working Conditions Survey.

Table 0.1. Register General’s Social Classes(11)

I. Professional
II. Intermediate
IIIn. Skilled non-manual
IIIm. Skilled manual
IV. Partly skilled
V. Unskilled

The European Working Condition Survey used the International Standard Classification of Occupation(ISCO) as the measurement of occupations. One advantage of using the ISCO could be the comparability among different countries.(12)While the Third Korean Working Conditions Survey used a similar occupational classification of RGSC, the Fourth Korean Working Conditions Survey used ISCO for the measurement of occupations.

Table 0.2. International standard classification of Occupation (ISCO)(12)

Legislator, senior official, managers
Professional
Technicians and associate professional
Clerks
Service, retail, sales workers
Skilled agricultural and fishery

Craft related trade workers

Plant and machine operators and assemblers

Elementary occupation

Working conditions and health

Occupations are one key component of social determinants of health, particularly in adulthood. The majority of people earn income by participating in the labor market. Working can have positive effects on physical and mental health. Working is also an important pathway for social participation, and working can enhance self-efficacy.(13-15) However, working can be harmful to health, as workers can be exposed to occupational hazards including physical, chemical, biological, ergonomic, and psychosocial hazards during their working time.(16)

A study estimated that globally, 2.3 million work-related deaths occurred a year. The largest proportion of these deaths was due to work-related diseases (2.0 million), and a smaller component was death due to occupational injury (0.3 million). The study also reported that the economic costs of work-related illness and injury were between 1.8% and 6.0% of estimated GDP, and the average cost might be 4% of GDP.(17)

Recently, a majority of research explored health inequalities which are related income inequalities (inequality in resources) between different socioeconomic groups and health inequalities related to social psychological factors including occupational stressors in the workplace.(18-24) On the other hand, occupational health has focused on the early detection of occupational disease or reducing the underreporting of work-related disease.(25) Although unequal exposure to occupational exposure by different occupations and employment status can be an important pathway of health inequality, few studies investigated health inequality related to workplace safety and various occupational hazard exposures except for psychosocial working conditions.(16, 26)

Occupational injury and occupational disease of Korea.

In Korea, 1,777 workers died from worked-related disease and injury in the year 2016. In the same year, 969 persons died from occupational injury, and 808 persons died from work-related disease. Work-related death more frequently occurred in construction and manufacturing. In particular, workers in small companies with less than 50 employees have experienced the problems.(27) Although inequalities in occupational injury and occupational disease across SES were insufficiently explored from the perspective of health equity, workers in a low SES are likely to bear the burden of exposure to dangerous and harmful

working conditions. Despite the decreasing trend, occupational injury is still prevalent in Korea. Furthermore, under-reporting of occupational injury is common, and official statistics on occupational injury and disease depend on worker compensation and does not include all occupational injuries.(28, 29) Under-reporting of occupational injury and disease could hinder from facing up the real size of the problems Korean society have to solve in workplaces.

Table 0.3. Official statistics of occupational injury and disease in South Korea(27)

	2010	2011	2012	2013	2014	2015	2016
Annual incidence rate of occupational injury (%)	0.69	0.65	0.59	0.59	0.53	0.5	0.49
Annual deaths due to occupational injury and disease	1,931	1,860	1,864	1,929	1,850	1,810	1,777
Annual fatal occupational injuries per 10,000 workers	0.78	0.79	0.73	0.71	0.58	0.53	0.53
Annual number of occupational diseases	7,803	7,247	7,472	7,627	7,678	7,919	7,876

Work related injury and Occupation hazard exposures in the Third Korean Working Conditions Survey

Work related Injury is more frequent than what is presented in official occupational injury statistics. The annual incidence of occupational injury is 0.5

percent in official statistics, yet the annual incidence was 1.6 percent in the survey. This gradient was seen in occupational injury across occupations. Manual workers experienced a higher risk of occupation injury. Also, workers under unstable employment more frequently experienced occupational injury in the same occupations.

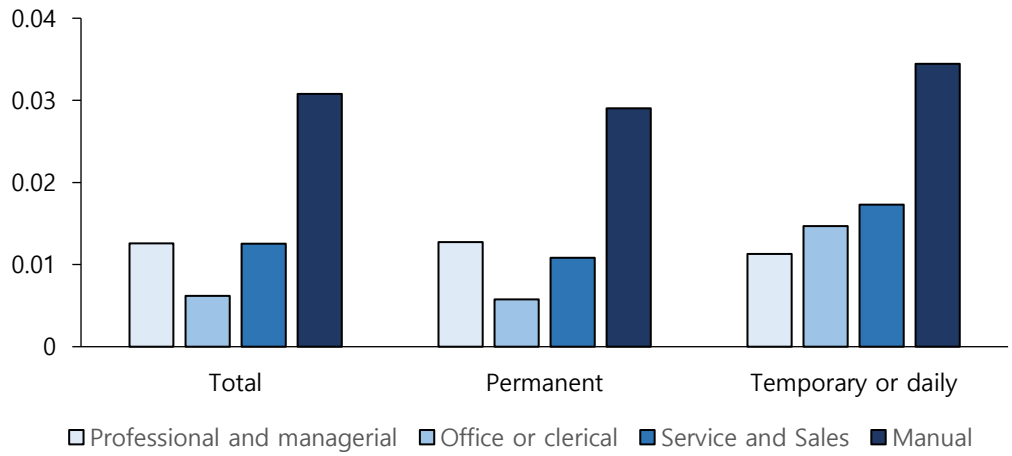

Figure 0.1. The gradient of work-related injury among Korean employees

Health inequality due to psychosocial factors and social relationships under hierarchical organizations in previous studies

The most well-known study on health inequality due to psychosocial factors and social relationships in hierarchical organizations might be the Whitehall Study II.

The Whitehall Study II observed the gradient in health among British civil servants. As the pathway of the health inequality, Whitehall study II extensively explored the association between psycho-social working conditions, such as low job control and effort reward imbalance, and health.(7, 8, 21) Recently published studies on the association between psychosocial working conditions and health reported the combined effect from the results of multiple occupational cohorts in European countries through meta-analysis. The effects of job strain, effort reward imbalance, and long working hours on health, particularly coronary heart disease from results from multiple occupational cohorts in European countries. All these psychosocial working conditions related with low SES increased the risks of coronary heart disease (HR of Job strain:1.3;(30) HR of effort reward imbalance:1.16(31); RR of long working hours[more than 55 hour per week]: 1.13).(32)

Health inequality due to the occupational hazards exposures including physical, chemical and ergonomic exposures in previous studies

Since the publication of the Whitehall Study II, the majority of research on health inequality studied psychosocial working conditions as the pathway to health inequality. Although contributions of physical, chemical, and ergonomic risks

were under-researched, several studies explored the contribution of these factors to health inequality.(33) A Finnish cross-sectional study reported physical work load and physical and chemical exposure contributed to health inequality in both women and men.(34) Similarly, a cross-sectional study in France demonstrated similar results.(35) These two studies reported changing proportions of prevalence ratio (PR) or odds ratio (OR) when adjusting occupational hazard exposure. Also, two papers in the same occupational cohort demonstrated that physical, chemical, and ergonomic working conditions have an impact on the health of the retired population and contributed to health inequality. A study reported that perceived ergonomic strain, dangerous working circumstance, history of occupational injury, and chemical exposures decreased the proportion of self-rated good health among persons aged 50 and 75, and another study of the same cohort showed the worsening of quality of life due to the ergonomic strain and dangerous working conditions.(36, 37)

Perceived risk of safety and health at work

Table 0.4. The association between perceived risk of safety and health at work and occupational exposures: univariable survey logistic regression analysis

	OR	95%CI	
Physical exposures			
Vibration	5.66	5.21	6.14
Noise	5.31	4.90	5.77

High temperature	4.34	3.99	4.72
Low temperature	2.81	2.55	3.09
Chemical &biologic exposures			
Dust, fume, smoke	5.45	5.02	5.92
Solvent, thinner	3.69	3.28	4.15
Chemical	2.83	2.52	3.18
Environmental smoking	3.37	3.05	3.72
Biologic hazards	2.72	2.34	3.16
Ergonomic exposures			
Painful posture	3.34	3.08	3.62
Heavy load	3.66	3.36	3.98
Long standing	1.95	1.80	2.11
Repeated hand or arm movement	2.25	2.07	2.45
Psychosocial exposures			
Perceived stress	1.22	1.12	1.33
Low job control	1.36	1.25	1.47
Hiding emotion	0.87	0.79	0.95
Shift work	2.57	2.31	2.86
Long working hours	1.84	1.69	2.00

In the thesis, the perceived risk of safety and health at work was employed as the measurement of general working conditions and workplace safety. Perceived risk of safety and health at work was assessed by the following question: “Do you think your health or safety is at risk because of your work?” “Yes” was regarded as “perceived risk of safety and health at work.” As seen in the Table 4, perceived risk of safety and health at work wasclosely linked with physical, chemical, ergonomic, and psychosocial working conditions.

Motivations for mediation analysis in health inequality

Socioeconomic status (SES) might be a fundamental factor in the increased likelihood of disease.(38) SES could affect well-known risk factors at the individual level such as smoking and alcohol consumption.(39) Social relationships and structures could shape resource distribution which affects health though multiple mechanisms. Although SES per se might generate health inequality, the majority of health inequality could be generated by several pathways. Material, psychosocial, behavioral and macro-social policy are proposed pathways to health inequality.(10) Furthermore, the magnitude and the slope of health inequality vary among different societies. The variance in magnitude and slope of inequalities could be explained by different social environments and levels of social inequality.(40) In public health, the description of health inequalities is often the foundation of a study. However, the goal of research on health inequality might be finding effective means of interventions to reduce health inequality and create social environments that enable the implementation of such interventions. To find an effective means of intervention, mediation analyses might be helpful. Recently proposed mediation analyses could directly estimate the contributive effect size through mediation, although many previous studies just compared the change of effect size (the changes of

ORs or RRs) after including mediating variables in the model. By mediating analysis, relatively important mechanisms could be elucidated and important pathways which generate health inequality with larger effects could be identified as points of intervention.(41-43) In this thesis, perceived risk at work (as general and comprehensive working conditions which were associated with safety at work and physical, chemical, ergonomic, and psychosocial working conditions), financial imbalance, low income, low job control, and long working hours were considered as mediators which could generate the health gap between manual workers and non-manuals workers. By estimating the proportion mediated, an important pathway for an intervention could be invetigated.(44)

Motivations for interaction analysis in health inequality.

Health inequality can be generated by accumulated exposures to adverse conditions which have a negative impact on health though the course of life. Persons in a low SES could be exposed to multiple risk factors, since individuals with a low SES generally live under more hazardous conditions and have scarce resources to cope with them. When the effects of exposure changed under simultaneous exposure another risk factor, the change of effect size is regarded as an interaction. In particular, in the case of the effect size of the combined

exposure being larger than the simple addition of the individual effect size, there is an interaction.(45)

Generally, there are two motivations for interaction analysis. First, interaction analysis could find a more vulnerable subpopulation or persons who could have more benefit when an intervention is implemented. Second, interaction analysis could broaden the understanding of mechanisms.(46) In this thesis, the main purpose of interaction analysis is to find a more vulnerable subpopulation among Korean working populations. To reduce health inequality, the policy priority might need to be centered on a more vulnerable subpopulation.

Most interaction analyses do not provide sufficient information on interaction. The majority of research does not report the effect size of the interaction based on the additive scale which is more related with a causal relationship. Recently, a study on interaction analysis recommended that researchers need to report both additive and multiplicative scales when conducting interaction analysis. For the additive scales, the RERI(Relative Excess Risk due to Interaction) should be reported, and for the multiplicative scales, the Ratio of RR should be reported.(47)

The location of the thesis in social determinants of health

This thesis will focus on occupations and employment status as indicators of

socioeconomic status (SES) and explore the contribution of occupational hazard exposure as a crucial pathway of health inequality. Occupational hazard exposures include physical, chemical, ergonomic, and psychosocial exposures.

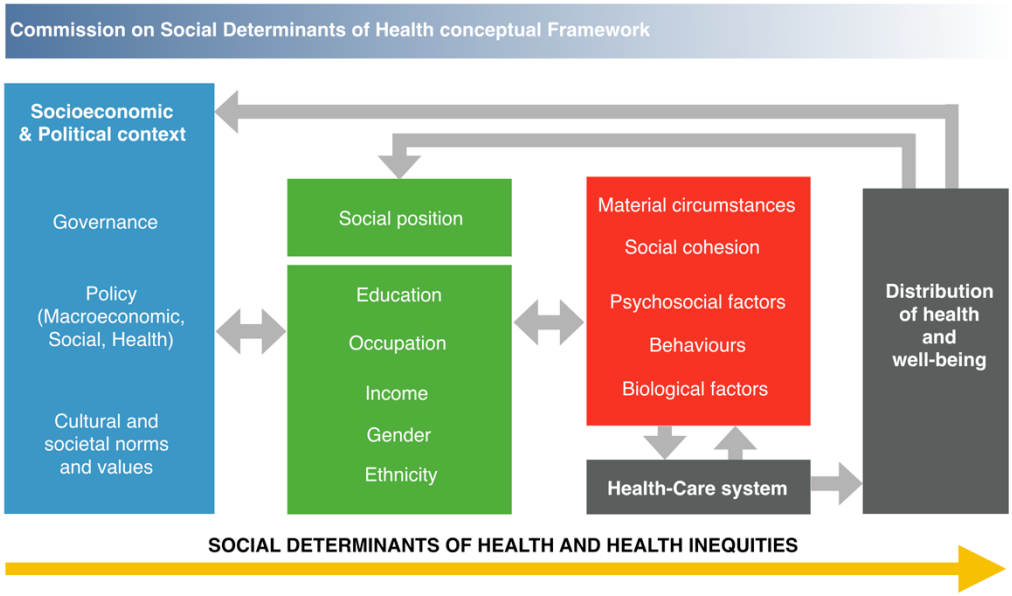

Figure 0.2. The location of the thesis in the conceptual framework of the Commission on Social Determinants of Health (Source: WHO CSDH, 2008). (48)

The aim and hypotheses of thesis

The main goal of this thesis is to explore the contributions of occupation hazard exposure to health inequality. In addition, this paper seeks to identify policy priorities among various occupational hazard exposures. Mediation analysis and interaction analysis were conducted to find important mediators and interactions

among several occupational hazard exposures. This thesis will examine hypotheses described below:

Hypothesis 1.

There might be gradients in occupational hazard exposures, including physical, chemical, ergonomic, and psychosocial exposures, across different occupations and employment status.

Hypothesis 2.

Occupational hazards exposures might affect health (in particular self-rated health and work-related injury).

Hypothesis 3.

Workplace safety and hazard exposures might contribute health inequality as the mediator between manual workers and non-manual workers, similar to material resource gaps. As the proxy of general workplace safety and hazards exposures, perceived risk of safety and health was employed as the main mediator for analysis. Also, long working hours and unstable employment could contribute to the health gap between manual workers and non-manual workers as mediators.

Hypothesis 4.

Perceived risk at work under unstable employment might be more harmful to health due to the interaction.

Hypothesis 5

Long working hours under low job control might have a more detrimental impact on health due to the interaction.

Chapter 1. Occupational hazard exposures by occupation and employment status among Korean employees.

Introduction

Occupations area vital social determinant of health. Working is important for social participation and self-efficacy.(13-15) However, working can be detrimental to health due to exposure to various occupation hazards.(16)

Physical hazards including vibration, noise, and high or low temperature can have adverse health effects. Vibration can cause diseases such as HAVS (Hand Arm Vibration Syndrome),(49, 50) and the exposure to whole body vibration is associated with musculoskeletal disorders including lower back pain.(51, 52) Noise exposure can cause noise-induced hearing loss and could cause sleep disturbance and psychological symptoms.(53-56) Working at high temperature can lead to severe diseases like heat stroke, and local heat rashes on the skin.(57, 58) Working at low temperature can cause severe systemic disease like hypothermia, and even frostbite of distal extremities.(59-61)

Chemical hazards can also cause various maladies. In particular, exposure to metals and organic solvents can cause various systemic disorders ranging from acute intoxication to chronic diseases.(62, 63) There are also a variety of neurologic, hematologic, hepatologic and nephrotic diseases that can result

from exposures to chemicals used in the workplaces.(64-67)

Ergonomic hazards can cause various musculoskeletal diseases, (68) and psychosocial hazards including job stress are closely linked with cardiovascular disease and mental disorders like depression.(18, 19, 69, 70) Biologic hazards can cause infectiousdiseases.

Although unequal exposure to occupational hazards (by different occupations and employment status) can be an important pathway of health inequality, Few studies have investigated health inequality related to workplace safety and various occupational hazard exposures with the exception of psychosocial stressors in the workplace.(16, 26)

The purpose of this chapter is twofold. First, it aims to assess the proportion of employees who were exposed to occupational hazards including physical, chemical, ergonomic, and psychosocial hazards by occupation and employment status. The chapter's another aim is to estimate the health effect of these occupational hazard exposures.

Method

Study Subjects

This chapter analyzed the raw data of the Third Korean Working Conditions Survey (KWCS) undertaken in 2011. The survey was conducted by trained

interviewers through face-to-face interviews under the leadership of the Korea Occupational Safety and Health Agency (KOSHA).(71)

The KWCS wished to assess the distribution of work-related risk factors in order to improve policy making in the area of occupational safety. The contents of the questionnaire were comparable to the European Working Conditions Survey. The KWCS used a nationally representative sample which included only the population which were economically active over 15 years in South Korea.(71)

The total sample size of the Third Korean Working Conditions Survey was 50,033 (unweighted sample size=50,032), and the sample size of employees was 35,903 (unweighted sample size=29,711).

Sampling and survey weighting

The survey sample was drawn from the population and housing census conducted in 2010. To be a representative sample of the economically active population over 15 years old, the unemployed, students, housewives, and retired persons were excluded from the sample. The sampling method employed a multistage stratified approach utilizing the probability proportional to size. Census districts were selected using probability according to the size of systematic sampling which reflected the number of households in the census district. Then, ten households were chosen at random within each selected

census district. Finally, one eligible person was interviewed in the selected household.

The survey weighting was calculated using the information on the distribution by region, locality, size, age, gender, occupations. Also, the response rate of interviewees was taken into account by calculating the survey weighting.

Study variables

Sociodemographic and behavioral characteristics

Information on age, sex, income, educational level, smoking, and alcohol consumption was collected by the questionnaire. Age was categorized as 15–29, 30–39, 40–49, 50-59, and 60 or more years. Education level was categorized as middle school (lower secondary education) or less, high school (higher secondary education), college, and university or more (post-secondary education, tertiary education, or more). Monthly income was divided into fourgroups by quartile. Alcohol consumption was categorized as none, moderate, or risky. Risky alcohol consumption was defined as drinking more than seven units of alcohol at one time (binge drinking) or drinking more than 14 units of alcohol per week. Smoking was classified into three groups: non-smokers, ex-smokers, or current smokers.

Occupation and employment

In the original questionnaire, occupations were divided into eight categories: professional, managerial, office, sales, service, skilled, semi-skilled, non-skilled, fishery, and farming. For the analysis, the eight categories were combined into four categories which were management and professional, office worker, sales and service, or manual (skilled, semi-skilled, non-skilled, farming and fishery). Employment status was assessed as regular, temporary, or daily. In the analysis, employment status was divided into two categories (regular vs. temporary or daily).

Occupational Hazard Exposures

When assessing physical and chemical exposures, the question asked was “Are you exposed at work to…?” Subcategory questions of physical and chemical exposures included “Vibrations from hand tools, machinery, etc.”, “Noise so loud that you would have to raise your voice to talk to people”, “High temperatures which make you perspire even when not working”, “Low temperatures whether indoors or outdoors”, “Breathing in smoke, fumes (such as welding or exhaust fumes), powder or dust (such as wood dust or mineral dust) etc.”, “Breathing in vapors such as solvents and thinners”, “Handling or being having skin contact with chemical products or substances”, “Handling or being in direct contact with

materials which can be infectious, such as waste, bodily fluids, laboratory materials, etc.", and "Tobacco smoke from other people", When interviewees responded "All of the time", "Almost all of the time", "Around ¾ of the time", "Around half of the time", or "Around ¼ of the time" it was regarded as physical and chemical exposure. When interviewees responded "Almost never" or "Never" it was regarded as no physical and chemical exposure.

When assessing ergonomic hazard exposures, the respondents were asked if they expreienced "Tiring or painful positions", "Lifting or moving people", "Carrying or moving heavy loads", "Standing," or "Repetitive hand or arm movements". If interviewees responded "All of the time", "Almost all of the time", "Around ¾ of the time", or "Around "half of the time," it was regarded as ergonomic hazard exposures. If interviewees answered "Around ¼ of the time", "Almost never", or "Never," it was regarded as no ergonomic hazard exposures.

For assessing psychosocial hazard exposure, the following items were employed: "You can influence decisions that are important for your work", "You experience stress in your work", and "Your job requires that you hide your feeling" When the response was "rarely" or "never" it was regarded as no exposure to psychosocial hazards, and when the response was "always," "most of the time" or "sometimes" it was regarded as exposure to psychosocial occupational hazards. For assessing exposure to shift work, respondents were

asked “Do you work shifts?”, “Yes” was regarded as exposure to shift work and “no” was regarded as no exposure to shift work. Perceived risk of safety or health at work was assessed by the question “"Do you think your health or safety is at risk because of your work?" “Yes” was regarded as a perceived risk at work and “no” was regarded as no perceived risk of safety or health at work.

When assessing safety and health at work and the availability of personal protective equipment, the following questions were asked: “Does your job ever require that you wear personal protective equipment (PPE)?”, “Do you always use it when it is required?”, “Regarding the health and safety risks related to the performance of your job, how well informed would you say you are”. Regarding the requirement of PPEs, “Yes” indicated that the job required PPEs and “No” indicated that the job did not require PPEs. For the use of PPEs, “Yes” was regarded as using PPEs when required and “No” was regarded as not using the PPEs when required. On providing information on safety and health, “Very well informed” or “Well informed” was regarded as informed; “Not very well informed” or “Not at all well informed” was regarded as poorly informed.

Measurement of health and occupational injury

Health is assessed by the question, “How is your health in general?”. “Very poor,” “poor,” or “fair” were regarded as indicating poor self-rated health, whereas “very

good" or "good" were considered as good self-rated health. Experience of occupation injury was assessed by asking the question "Over the past 12 months, did you suffer from injury?" When an injury occurred during work, the injuries were considered as occupational injuries.

Directed Acyclic Diagrams (DAGs) and model selections.

For the model selection, a DAG was undertaken. First, the relationship among exposure variables, covariates, and the health outcome (conceptual causal diagram) was drawn. Second under an assumed causal relationship, minimal sufficient adjustment sets were identified by using the online program DAGitty.(72)

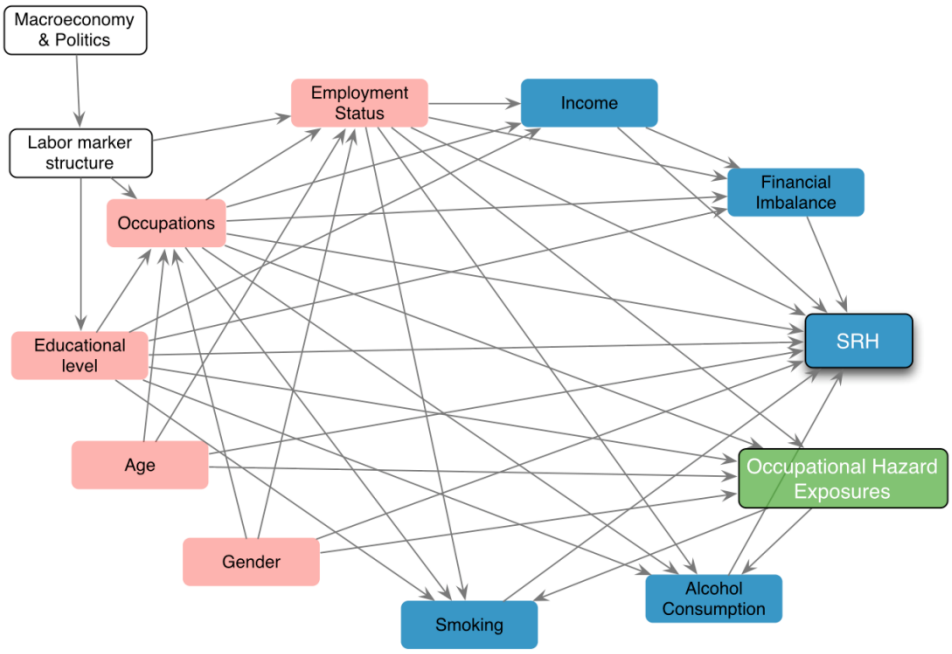

Figure 1.1. The conceptual diagram of Chapter 1: Occupational Hazard exposures and self-rated health

Statistical Analysis

The proportions were calculated by occupation and employment status with survey weighting (svy:tab). The influence of occupational hazard exposure on self-rated health and occupational injury were assessed through a multiple survey logistic analysis. All statistical analyses were undertaken using Stata (Version 13.1).

Results

Characteristics of the study population

The percent of female employees was 41percent. Sixty percent of participants were in their thirties and forties. Thirty-four percent of participants were current smokers, and 28 percent of participants were risky alcohol consumers. More than half of participants finished college and university. The percent of sale and service workers was 27, and the percent of manual workers was 34. In terms of employment status, 20 percent of employees were temporary and daily workers.

Table 1.1. The Characteristics of the Study Population

	N	Proportion		N	Proportion
Sex			Alcohol consumption		
Female	14618	0.41	No	8216	0.23
Male	21286	0.59	Moderate	17526	0.49
Age			Risky	10162	0.28
15-29	5589	0.16	Education		
30-39	10972	0.31	Middle school <	2643	0.08
40-49	10488	0.29	High School	13155	0.38
50-59	6058	0.17	College	6352	0.18
60+	2796	0.08	University	12497	0.36
Smoking			Employment		
No	19614	0.55	Regular	28543	0.8
Ex	4037	0.11	Temporary	5078	0.14
Current	12252	0.34	Daily	2283	0.06
Occupational			Income		
Professional & management	3095	0.09	Lowest	7944	0.23
			Low middle	9223	0.26
Office	10682	0.3	High middle	9164	0.26

	N	Proportion		N	Proportion
Sales & Service	9846	0.27	Highest	8844	0.25
Manual	12281	0.34			

Physical hazard exposures

Manual workers, and service and sales workers were more exposed to physical occupational hazards during work regardless of employment status. Regarding exposure to vibration and noise, a higher proportion of manual workers were exposed to noise (45%) and vibration (55%) than other occupations. On exposures to high temperature and low temperature, manual workers, Particularly employees under unstable employment were more often exposed to high temperature (41%) and low temperature (26%). Regarding the perceived risk of safety or health at work, manual workers under unstable employment had the highest proportion (24%).

Table 1.2. Physical hazard exposures and perceived risk at work by occupation and employment status among Korean employees

	Total		Permanent		Temporary and daily	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N (proportion)	Exposure(+) N (proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Vibration						
Professional & manage	2821(0.91)	274(0.09)	2572(0.91)	262(0.09)	249(0.96)	11(0.04)
Office	9779(0.92)	903(0.8)	9327(0.91)	867(0.09)	451(0.93)	36(0.07)
Service & sales	8458(0.86)	1387(0.14)	6172(0.86)	1033(0.14)	2287(0.87)	354(0.13)
Manual	5521(0.45)	6759(0.55)	3341(0.40)	4966(0.60)	2180(0.55)	1792(0.45)
Noise						
Professional & manage	2661(0.86)	434.(0.14)	2430(0.86)	404(0.14)	231(0.89)	29(0.11)
Office	9892(0.93)	789(0.07)	9446(0.93)	748(0.07)	446(0.92)	41(0.08)
Service & sales	8507(0.86)	1339(0.14)	6292(0.87)	914(0.13)	2215(0.84)	426(0.16)
Manual	6744(0.55)	5537(0.45)	4393(0.53)	3916(0.47)	2351(0.59)	1621(0.41)
High Temperature						
Professional & manage	2882(0.93)	212(0.07)	2638(0.93)	197(0.07)	245(0.94)	16(0.06)
Office	10031(0.94)	651(0.06)	9679(0.94)	615(0.06)	451(0.93)	36(0.07)
Service & sales	8614(0.87)	1232(0.13)	6328(0.88)	877(0.12)	2287(0.87)	354(0.13)
Manual	7819(0.64)	4461(0.36)	5461(0.66)	2847(0.34)	2358(0.59)	1614(0.41)
Low Temperature						
Professional & manage	2903(0.94)	192(0.06)	2653(0.94)	181(0.06)	249(0.96)	11(0.04)
Office	10102(0.95)	580(0.05)	9650(0.95)	544(0.05)	452(0.93)	35(0.07)
Service & sales	9052(0.92)	793(0.08)	6673(0.93)	533(0.07)	2380(0.90)	260(0.10)
Manual	9554(0.78)	2725(0.22)	6630(0.80)	1678(0.20)	2924(0.74)	1047(0.26)
Perceived risk of safety and health at work						
Professional & manage	2893(0.93)	201(0.07)	2641(0.93)	193(0.07)	252(0.97)	8(0.03)
Office	10326(0.97)	355(0.03)	9849(0.97)	345(0.03)	476(0.98)	11(0.02)
Service & sales	9123(0.93)	723(0.07)	6683(0.93)	521(0.07)	2440(0.92)	201(0.08)
Manual	9532(0.78)	2747(0.22)	6513(0.78)	1795(0.22)	3019(0.76)	953(0.24)

Chemical and biologic hazard exposures

Manual workers were more exposed to dust, fume, smoke, solvent, chemicals, possibly infection agents and environmental smoking. Forty-three percent of manual workers were exposed to dust, fume, or smoke; 14% of manual worker were exposed to solvent or thinner; 15% of manual workers came in contact with chemicals; 19% of manual workers were exposed to environmental smoking; and 7% of manual workers handled possibly infectious agents. The exposure disparity between stable employment and unstable employment was the largest with environmental smoking (permanent [16%] vs temporary or daily [25%]).

Table1. 3. Chemical hazard exposures by occupation and employment status among Korean employees

	Total		Permanent		Temporary and daily	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Dust, fume, smoke						
Professional & manage	2762(0.89)	333(0.11)	2526(0.89)	308(0.11)	236(0.91)	24(0.09)
Office	10081(0.94)	600(0.06)	9625(0.94)	560(0.06)	457(0.94)	30(0.06)
Service & sales	8868(0.90)	977(0.10)	6478(0.90)	727(0.10)	2390(0.91)	250(0.09)
Manual	6980(0.57)	5300(0.43)	4767(0.57)	3541(0.43)	2213(0.56)	1759(0.44)
Solvents						
Professional & manage	3019(0.98)	76(0.02)	2765(0.98)	69(0.02)	253(0.98)	6(0.02)
Office	104463(0.98)	218(0.02)	9995(0.98)	200(0.02)	469(0.96)	19(0.04)
Service & sales	9620(0.98)	226(0.02)	7041(0.98)	165(0.02)	2579(0.99)	61(0.02)
Manual	10513(0.86)	1767(0.14)	7031(0.85)	1277(0.15)	3482(0.88)	490(0.12)
Contact with chemicals						
Professional & manage	2968(0.96)	127(0.04)	2717(0.96)	118(0.04)	250(0.96)	10(0.04)
Office	10401(0.97)	280(0.03)	9929(0.97)	265(0.03)	471(0.97)	15(0.03)
Service & sales	9442(0.96)	403(0.04)	6897(0.96)	308(0.04)	2546(0.96)	95(0.04)
Manual	10413(0.85)	1867(0.15)	6955(0.84)	1353(0.16)	3457(0.87)	515(0.13)
Environmental smoking						
Professional & manage	2969(0.96)	126(0.04)	2722(0.96)	112(0.04)	246(0.95)	13(0.05)
Office	10087(0.94)	595(0.06)	9623(0.94)	572(0.06)	464(0.95)	23(0.05)
Service & sales	9032(0.92)	813(0.08)	6677(0.93)	528(0.07)	2355(0.89)	285(0.11)
Manual	9942(0.81)	2338(0.19)	6952(0.84)	1356(0.16)	2989(0.75)	983(0.25)
Possibly infectious agents						
Professional & manage	2998(0.97)	96(0.03)	2748(0.97)	86(0.03)	250(0.96)	10(0.04)
Office	10511(0.98)	170(0.02)	10037(0.98)	158(0.02)	474(0.97)	13(0.02)
Service & sales	9530(0.97)	316(0.03)	6964(0.97)	241(0.03)	2566(0.97)	75(0.03)
Manual	11433(0.93)	848(0.07)	7764(0.93)	544(0.07)	3669(0.92)	303(0.07)

Psychosocial hazard exposures

A low proportion of professional and managerial employees reported low job control, while a high proportion of manual workers reported low job control. Inversely, a higher proportion of employees in professional and managerial roles experienced perceived stress than in any other occupation; manual workers experienced the lowest proportion of perceived stress. The highest proportion of employees that had to hide their own emotions due to their work (32%) were in sales and service occupations. In contrast, manual workers made up the lowest proportion of employees who needed to hide their own emotion. The highest proportion of manual workers was engaged with shift work (15%).

Table 1.4. Psychosocial hazard exposures by occupation and employment status among Korean employees

	Total		Permanent		Temporary and daily	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Low job decision						
Professional & manage	3742(0.83)	763(0.17)	3209(0.84)	623(0.16)	469(0.79)	123(0.21)
Office	3514(0.66)	1778(0.44)	3058(0.68)	1418(0.32)	390(0.56)	303(0.44)
Service & sales	1742(0.58)	1287(0.42)	1352(0.62)	814(0.38)	340(0.44)	425(0.56)
Manual	2696(0.49)	2753(0.51)	2216(0.53)	1958(0.47)	420(0.37)	707(0.63)
Perceived stress						
Professional & manage	3206(0.71)	1322(0.29)	2716(0.71)	1135(0.29)	427(0.72)	168(0.28)
Office	3880(0.73)	1444(0.27)	3252(0.72)	1250(0.28)	536(0.77)	162(0.23)
Service & sales	2264(0.74)	800(0.26)	3251(0.73)	1250(0.27)	595(0.77)	180(0.23)
Manual	4213(0.77)	1273(0.23)	3215(0.77)	983(0.23)	874(0.77)	263(0.23)
High own emotion						
Professional & manage	2205(0.72)	889(0.28)	2011(0.71)	823(0.29)	193(0.74)	66(0.26)
Office	7587(0.71)	3094(0.29)	7214(0.71)	2980(0.29)	374(0.77)	113(0.23)
Service & sales	6695(0.69)	3151(0.32)	4757(0.66)	2448(0.34)	1938(0.73)	702(0.27)
Manual	9889(0.81)	2391(0.19)	6603(0.79)	1705(0.21)	3286(0.83)	686(0.17)
Low working hours						
Professional & manage	2441(0.87)	379(0.13)	2331(0.86)	359(0.13)	110(0.85)	20(0.15)
Office	9186(0.88)	1253(0.12)	8839(0.88)	1201(0.12)	347(0.87)	52(0.13)
Service & sales	5049(0.58)	3731(0.42)	3973(0.58)	2900(0.42)	1076(0.56)	832(0.44)
Manual	6613(0.61)	4204(0.39)	4969(0.62)	3063(0.38)	1643(0.59)	1141(0.41)

Ergonomic hazards exposures

In general, manual, service and sales workers were involved with various ergonomic hazards. Manual workers under unstable employment were exposed to the highest proportion of tiring or painful position (53%). Similarly, manual workers under unstable employment had the highest proportion of exposure to heavy loads (41%) and repetitive movements (73%).

Table 1.5. Ergonomic hazard exposures by occupation and employment status among Korean employees

	Total		Permanent		Temporary and daily	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Tiring or painful posture						
Professional & manage	2466(0.80)	629(0.20)	2259(0.80)	575(0.20)	207(0.79)	53(0.21)
Office	9220(0.86)	1461(0.14)	8810(0.86)	1385(0.14)	411(0.84)	76(0.16)
Service & sales	6934(0.70)	2912(0.30)	5123(0.71)	2081(0.29)	1811(0.69)	830(0.31)
Manual	6583(0.54)	5697(0.46)	4716(0.57)	3591(0.43)	1866(0.47)	2105(0.53)
Lifting or moving people						
Professional & manage	2979(0.96)	115(0.04)	2726(0.96)	108(0.04)	253(0.97)	7(0.03)
Office	10560(0.99)	121(0.01)	100085(0.99)	110(0.01)	475(0.98)	12(0.02)
Service & sales	9164(0.93)	683(0.07)	6725(0.93)	480(0.07)	2439(0.92)	202(0.08)
Manual	11452(0.93)	828(0.07)	7786(0.94)	522(0.06)	3666(0.92)	305(0.08)
Heavy loads						
Professional & manage	2969(0.96)	125(0.04)	2715(0.96)	119(0.04)	254(0.98)	6(0.02)
Office	10303(0.96)	379(0.04)	9839(0.97)	354(0.03)	463(0.95)	24(0.05)
Service & sales	8064(0.82)	1782(0.18)	5954(0.83)	1250(0.17)	2109(0.80)	531(0.20)
Manual	8282(0.67)	1782(0.33)	5943(0.72)	2364(0.28)	2338(0.59)	1634(0.41)
Standing						
Professional & manage	1515(0.49)	1580(0.51)	1402(0.49)	1432(0.51)	112(0.43)	147(0.57)
Office	9409(0.88)	1271(0.12)	9017(0.88)	1177(0.12)	392(0.80)	95(0.20)
Service & sales	3944(0.40)	5901(0.60)	2974(0.41)	4231(0.59)	970(0.37)	1670(0.63)
Manual	5185(0.42)	9095(0.58)	3865(0.47)	4442(0.53)	1320(0.33)	2652(0.67)
Repetitive movements						
Professional & manage	1788(0.58)	1306(0.42)	1644(0.58)	1190(0.42)	144(0.55)	115(0.45)
Office	6987(0.65)	3695(0.35)	6696(0.66)	3499(0.34)	290(0.60)	197(0.40)
Service & sales	4731(0.48)	5114(0.52)	3551(0.49)	3654(0.51)	1180(0.45)	1461(0.55)
Manual	3793(0.31)	8488(0.69)	2728(0.33)	5580(0.67)	1065(0.27)	2908(0.73)

Personal protective equipments (PPEs) and providing information on safety and health

Regarding the requirement of PPEs, the highest proportion of employees that responded that their job required PPEs was among manual workers. There was the gap in the use of PPEs when required between stable employment and unstable employment. Regarding information on safety and health, more than 25% of employees were not provided sufficient information on safety and health at work regardless of occupation. The proportion of insufficient information on safety and health was highest among service and sales workers (42%). The gap between different employment status was 10 percent or larger across different occupations and the gap was the largest among manual workers.

Table 1.6. Personal protective equipment and providing information on safety and health by occupation and employment status among Korean employees

	Total		Permanent		Temporary and daily	
	No	Yes	No	Yes	No	Yes
	N(Proportion)	N(Proportion)	N(Proportion)	N(Proportion)	N(Proportion)	N(Proportion)
PPES requirement						
Professional & manage	2712(0.88)	382(0.12)	2471(0.87)	363(0.13)	241(0.93)	19(0.07)
Office	9997(0.94)	685(0.06)	9527(0.93)	667(0.07)	470(0.96)	17(0.04)
Service & sales	8499(0.86)	1347(0.14)	6196(0.86)	1009(0.14)	2302(0.87)	339(0.13)
Manual	6205(0.51)	6075(0.49)	4083(0.49)	4224(0.51)	2121(0.53)	1851(0.47)
Not using PPES when required						
Professional & manage	342(0.89)	40(0.11)	327(0.90)	36(0.10)	15(0.79)	4(0.21)
Office	598(0.87)	86(0.13)	586(0.88)	82(0.12)	12(0.73)	5(0.27)
Service & sales	1185(0.88)	162(0.12)	880(0.87)	129(0.13)	305(0.90)	33(0.10)
Manual	5483(0.90)	592(0.10)	3849(0.91)	375(0.09)	1634(0.88)	217(0.12)
Poorly provided information on safety and health						
Professional & manage	1707(0.75)	556(0.25)	1597(0.77)	484(0.23)	109(0.60)	71(0.40)
Office	5227(0.69)	2383(0.31)	5052(0.69)	2243(0.31)	175(0.55)	140(0.44)
Service & sales	4192(0.58)	3090(0.42)	3260(0.60)	2157(0.40)	932(0.50)	934(0.50)
Manual	7397(0.68)	3429(0.32)	5460(0.73)	2021(0.27)	1938(0.58)	1408(0.42)

Occupational hazard exposure among EU employees

Occupational hazard exposures by occupation and employment status in 15 EU countries were explored in the appendix tables (appendix tables 1- 10). In the analysis, gradients were observed in most occupational exposures similar to Korean employees.

Occupational hazard exposures and Self-rated health

Among all employees, most occupational hazard exposures were associated with poor-self rated health. However, exposure to low temperature and hiding emotion were not significantly linked with poor self-rated health. Perceived risk at work had the largest OR (2.19) and painful posture had the second largest OR (1.65).

Although statistical significance was not seen in between several occupational hazard exposures and self-rated health, and the magnitude of ORs decreased, among manual workers the associations between the majority of occupational hazard exposures and poor-self rated health were observed. Noise, high temperature, contact with chemicals, environmental smoking, painful posture, heavy load, perceived stress, low job control, and long working hours were statistically significant in their association with poor-self rated health. Perceived risk at work had the largest OR (2.35) and painful posture had second largest

OR (1.38).

Table 1.7. Occupational hazard exposures and poor self-rated health among Korean employees*****

	Unadjusted			Model 1			Model2		
	OR	95%CI		OR	95%CI		OR	95%CI	
Perceived risk at work	2.37	2.19	2.57	2.16	1.97	2.36	2.19	2.01	2.40
Physical exposure									
Vibration	1.30	1.23	1.38	1.15	1.07	1.24	1.15	1.07	1.24
Noise	1.32	1.24	1.41	1.16	1.08	1.25	1.17	1.08	1.25
High temperature	1.45	1.35	1.55	1.15	1.07	1.24	1.15	1.06	1.24
Low temperature	1.29	1.19	1.40	1.05	0.96	1.15	1.04	0.95	1.14
Chemical exposure									
Dust, fume, smoke	1.37	1.29	1.46	1.09	1.01	1.17	1.09	1.01	1.18
Solvent, thinner	1.28	1.16	1.43	1.16	1.03	1.30	1.16	1.03	1.30
Chemical contact	1.24	1.12	1.37	1.13	1.01	1.25	1.13	1.01	1.26
Environmental smoking	1.51	1.39	1.64	1.32	1.20	1.44	1.32	1.20	1.44
Ergonomic exposure									
Painful posture	1.89	1.79	2.00	1.65	1.55	1.76	1.65	1.55	1.76
Heavy load	1.57	1.47	1.68	1.32	1.22	1.42	1.31	1.22	1.42
Repetitive movement	1.25	1.19	1.32	1.08	1.02	1.15	1.08	1.02	1.15
Psychosocial exposure									
Perceived stress	1.13	1.07	1.21	1.26	1.18	1.35	1.27	1.19	1.36
Low job control	1.29	1.22	1.37	1.09	1.03	1.16	1.09	1.02	1.15
Long working hours	1.39	1.31	1.48	1.30	1.22	1.40	1.31	1.22	1.40
Hiding emotion	0.94	0.88	1.00	1.03	0.96	1.10	1.02	0.96	1.09

*ORs and 95%CIs were estimated by survey logistic analysis

Model 1: adjusted by age, gender, education, employment status, and occupations (total effect)

Model 2: adjusted by variables in model 1 + smoking, and alcohol consumption (direct effect)

Table 1.8. Occupational hazard exposures and poor self-rated health among Korean manual workers*****

	Unadjusted			Model 1			Model2		
	OR	95%CI		OR	95%CI		OR	95%CI	
Perceived risk at work	2.05	1.85	2.27	2.29	2.04	2.57	2.35	2.09	2.64
Physical exposure									
Vibration	0.87	0.79	0.95	1.09	0.98	1.20	1.10	0.99	1.22
Noise	0.96	0.88	1.04	1.10	1.00	1.22	1.11	1.00	1.22
High temperature	1.19	1.08	1.30	1.17	1.06	1.30	1.18	1.07	1.30
Low temperature	1.08	0.97	1.20	1.04	0.93	1.17	1.04	0.93	1.17
Chemical exposure									
Dust, fume, smoke	1.04	0.96	1.14	1.05	0.95	1.15	1.05	0.96	1.16
Solvent, thinner	0.96	0.85	1.09	1.12	0.98	1.28	1.12	0.98	1.29
Chemical contact	1.00	0.89	1.13	1.15	1.00	1.31	1.15	1.01	1.32
Environmental smoking	1.25	1.12	1.40	1.27	1.13	1.44	1.28	1.13	1.45
Ergonomic exposure									
Painful posture	1.47	1.34	1.60	1.37	1.25	1.51	1.38	1.25	1.52
Heavy load	1.17	1.06	1.28	1.17	1.06	1.30	1.18	1.06	1.30
Repetitive movement	1.12	1.02	1.23	1.05	0.95	1.16	1.05	0.95	1.17
Psychosocial exposure									
Perceived stress	1.21	1.09	1.35	1.36	1.21	1.53	1.36	1.21	1.53
Low job control	1.37	1.25	1.49	1.17	1.07	1.29	1.17	1.06	1.29
Long working hours	1.31	1.19	1.44	1.37	1.24	1.52	1.35	1.22	1.49
Hiding emotion	0.98	0.88	1.09	1.02	0.90	1.15	1.02	0.90	1.15

* ORs and 95%CIs were estimated by survey logistic analysis

Model 1: adjusted by age, gender, education, employment status, and occupations (total effect)

Model 2: adjusted by variables in model 1 + smoking, and alcohol consumption (direct effect)

The influence of perceived risk at work and ergonomic hazard exposure to occupational injury

Perceived risk at work increased the risk of injury in all employees (OR: 4.33) and especially manual workers (OR: 3.40). Also, a heavy load increased the risk of work-related injury in both employees (OR: 2.11) and manual workers (OR: 1.99). Additionally, painful posture increased the risk of work-related injury in both employees (OR: 1.77) and manual workers (OR: 1.74). Repetitive movement did not increase the risk of work-related injury in both employees and manual workers.

Table 1.9. The perceived risk and ergonomic hazard exposures on occupational injury among Korean employees *****

	Unadjusted			Model 1		
	OR	95%CI		OR	95%CI	
Perceived risk at work	3.78	2.98	4.79	4.33	3.43	5.45
Painful posture	1.71	1.35	2.17	1.71	1.40	2.09
Heavy load	2.20	1.74	2.79	2.11	1.70	2.63
Repetitive movement	0.88	0.69	1.12	1.04	0.85	1.27

* ORs and 95%CIs were estimated by survey logistic analysis

Model 1: adjusted by age, gender, education, employment status, and occupations

Table 1.10. The perceived risk and ergonomic hazard exposures on occupational injury among Korean manual workers *

	Unadjusted			Model 1		
	OR	95%CI		OR	95%CI	
Perceived risk at work	3.78	2.98	4.79	3.40	2.61	4.44
Painful posture	1.71	1.35	2.17	1.74	1.34	2.26
Heavy load	2.20	1.74	2.79	1.99	1.55	2.57
Repetitive movement	0.88	0.69	1.12	0.86	0.66	1.12

* ORs and 95%CIs were estimated by survey logistic analysis

Model 1: adjusted by age, gender, education, employment status

Discussion

In this thesis, inequality in exposures to occupational hazards across occupations was observed. Exceptionally, professional and managerial occupation were more exposed to perceived stress and hiding emotions. Regarding employment status, generally higher proportions of workers under unstable employment were exposed to occupational hazards compared to workers under stable employment. Exposure to noise, vibration, solvent, and chemicals was more common for workers with stable employment. These results demonstrated the unequal burdens which workers in a low socioeconomic status (SES) and workers under unstable employment have to bear in order to maintain the current production system of Korean society. Furthermore, the majority of occupational hazard exposure increased the risk of poor self-rated health in both all employees and manual workers. Perceived risk and ergonomic hazard exposure also increased the risk of occupation injury. This result suggested that occupational hazard could be an important pathway to health inequality among the working population.

The results implied that working conditions, including occupational hazard exposures, should be improved by the principle of proportionate universalism in order to reduce health inequality among the working population.(73, 74) Working conditions of manual workers and workers

under unstable employment status should be improved with higher priority, and general working conditions should be improved for the entire working population at the same time.

One advantage of this study is that it had a relatively large sample size (weighted sample size:35904) and a nationally representative sample. Furthermore, this study sample selected by a systematic sampling method.(75)

The subjective nature of the exposure assessments based on the questionnaire could be a significant limitation of this study. The assessment of working conditions based on the exposure time using the questionnaire was carried out by interview. In future studies, a more objective measurement of working conditions by professional industrial hygienists with a smaller proportion of this sample might be required. The comparison between subjective measures and exposure assessments by professional industrial hygienists could allow for more reliable occupational hazard exposure assessments. The cross-sectional nature of the study design is another limitation

Conclusion

In this chapter, gradients in occupational hazard exposures among different occupations and occupational hazard exposure disparities

between stable employment and unstable employment were observed. Furthermore, occupational hazard exposure increased the proportion of poor self-rated health and occupational injury. This result suggested that occupational hazard exposure could be an important path to health inequality among the population in economically active ages.

Chapter 2. The decomposition of the health gap between manual and non-manual employees by mediation analyses

Introduction

Health inequality results from the cumulative exposure to risk factors and ameliorating factors throughout the life course.(76) Health inequality could be explained by material, psycho-social, and cultural and behavioral factors.(5) Health inequality due to material factors is explained by the avaiable resource gaps which could generate health inequality among different social groups. Psychosocial factors explain the health gap by differences in exposure to harmful psychological factors, such as job stressors among different social groups and other stressful living conditions (e.g., divorce). Cultural and behavioral factors such as, smoking and alcohol consumption could also contribute to health inequality. Health inequality among different occupations can be explained by all three of these factors. However, each path does not exclude other paths.(10)

In adulthood, working is closely linked to the generation of health inequalities. Work could have positive or negative impacts on health. First, work is the main source of income. The majority of people earn income by participating in the labor market and income is the material

basis for maintaining health. Income inequalities can lead to health inequalities due to material differences such as available resources necessary to maintain health (nutrition, housing, clothing, use of health care services, etc.).(77) Furthermore, work in itself could be beneficial or harmful to health. Moderate levels of working could be beneficial to health. Decent work is associated with better self-esteem and broader social relationships which could positively affect health. However, workers' health could worsen through exposure to various occupational hazards including physical, chemical, ergonomic, and psychosocial risk factors.(78) In developing countries and newly developed countries such as Korea, industrial accidents and acute intoxication in the workplaces have been a serious social problem.(79, 80) Different exposure levels to dangerous and hazardous working conditions across different occupations and between different employment statuses could contribute to these health inequalities. (33) An even worse problem in developing countries and newly industrialized countries has been the under-reporting and concealment of industrial accidents and intoxication. Under-reporting and concealment of industrial accidents and intoxications can prohibit face up the reality and proper measurements cannot be made without recognizing the real problems.(81)

The health gap between manual workers and non-manual workers is

well-known to health researchers. This gap could be explained by material, psychosocial, cultural, and health behaviors. However, the relative contributing effect size of each path is rarely estimated by using mediation analysis. Through mediation analysis under the counterfactual frame, the direct effect of exposure and the indirect effect of the mediating path can be decomposed.(43) Also, mediation analysis under the counterfactual frame could accurately calculate natural indirect effect and the proportion mediated.(82) To evaluate relative contributory effect sizes by possible mediating paths on the health gap between manual workers and non-manual workers, mediation analyses were undertaken. In this analysis, mediating variables were the perceived risk of safety and health at work (general working conditions related to safety and health), income (lower vs. higher), low job control, financial imbalance, and employment status. Estimating the relative contributory effect sizes could be helpful in setting the policy priority in occupational health and safety. Thus, the aim of this chapter is to undertake the mediation analysis in order to decompose the health disparity between manual workers and non-manual workers.

Method

Study population

The study population of this chapter was employees of the Third Korean Working Conditions Survey (KWCS).

Study variable

Occupations (exposure variable) and health status

Occupations were classified into two categories. The non-manual category included professional, managerial, office, and clerical jobs. The manual category included service and sales workers and blue-collar workers. Health status was estimated by self-rated health and classified into two groups. “Very poor” “Poor” and “Fair” were regarded as poor health and “Good” and “Very Good” were regarded as good health.

Mediating variables

All mediating variables were classified into two groups. Mediating variables were the perceived risk of safety and health at work (yes vs. no), financial imbalance (yes vs. no), employment status (stable vs. unstable), income (higher vs. lower), low job control (yes vs. no) and long working hours (within legal limit [36-52 hours] vs. more than legal limit [more than 52 hours])

Confounders

Cofounders were age, gender, smoking (No smoking, past smoking, current smoking), alcohol (No alcohol drinking, moderate alcohol drinking, risky alcohol drinking). Risky alcohol drinking was defined as drinking more than six units of alcohol a day or drinking more than twelve units of alcohol a week.

Statistical Analysis

Total effects, natural direct effects, and natural indirect effects were calculated with “paramed”. “paramed” is the user-made Stata command for mediation analysis under the counterfactual frame.(83) Proportions mediated and 95% confidence intervals were calculated with “medeff” which is also the user-made Stata command for causal mediation analysis.(44)

The mathematical expression of total effect, natural direct effect,and natural indirect effect were as follows:(82)

$$\mathrm{OR}^{\mathrm{TE}}_{a,a^*|c} = \frac{P(Y_a = 1|\, c)/\{1 - P(Y_a = 1|\, c)\}}{P(Y_{a^*} = 1|\, c)/\{1 - P(Y_{a^*} = 1|\, c)\}}$$

Fig 2.1. Total effect (Source: VanderWeele TJ, Vansteelandt S, 2010) (82)

$$\mathrm{OR}^{\mathrm{NDE}}_{a,a^*|c}(a^*) = \frac{P(Y_{aM_{a^*}} = 1|\ c)/\{1 - P(Y_{aM_{a^*}} = 1|\ c)\}}{P(Y_{a^*M_{a^*}} = 1|\ c)/\{1 - P(Y_{a^*M_{a^*}} = 1|\ c)\}}.$$

Fig 2.2. Natural Direct Effect (Source: VanderWeele TJ, Vansteelandt S, 2010) (82)

$$\mathrm{OR}^{\mathrm{NIE}}_{a,a^*|c}(a) = \frac{P(Y_{aM_a} = 1|\ c)/\{1 - P(Y_{aM_a} = 1|\ c)\}}{P(Y_{aM_{a^*}} = 1|\ c)/\{1 - P(Y_{aM_{a^*}} = 1|\ c)\}}$$

Fig 2.3. Natural Indirect Effect (Source: VanderWeele TJ, Vansteelandt S, 2010) (82)

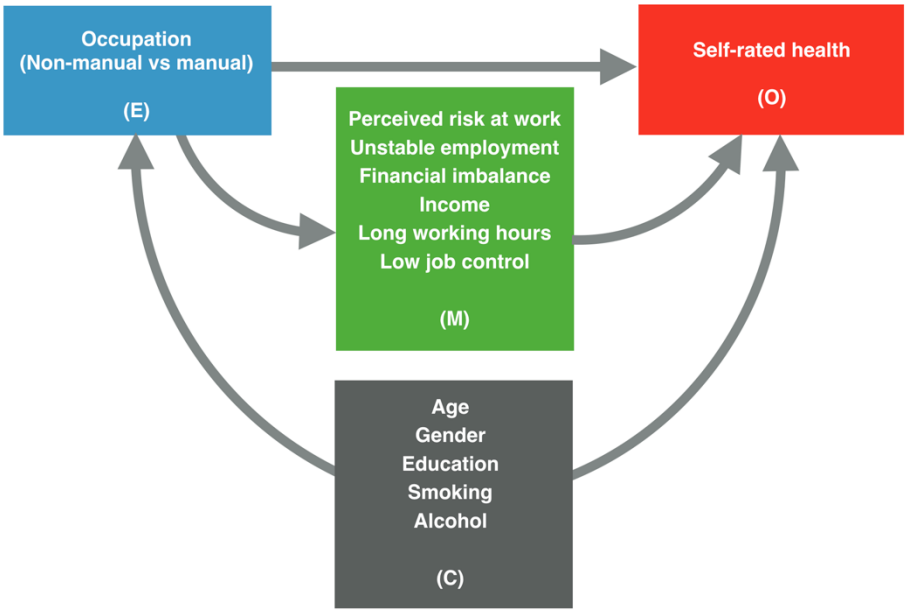

Figure 2.4. Conceptual diagram of health gap mediated by perceived risk at work, financial imbalance, income, low job control, and unstable employment between non-manual workers and manual workers. [(E): exposure, (C): confounders, (M): mediators (O): outcome]

Results

The proportion of elderly workers was higher among manual employees. A higher proportion of manual workers were current smokers. Generally, manual workers were more likely to experience unfavorable social and working circumstances. Higher proportions of manual workers reported a

perceived risk at work (14%), low job control (45%), financial imbalance (59%), unstable employment (30%), and lower income (64%).

Table 2.1. Characteristics of study population

	Non-manual		Manual		Total		p
	N	Percent	N	Percent	N	Percent	
Age							p< 0.001
15-29	1,574	15.34	3,330	17.12	4,904	16.51	
30-39	4,036	39.34	4,883	25.1	8,919	30.02	
40-49	3,202	31.21	5,332	27.41	8,534	28.72	
50-59	1,260	12.28	3,759	19.33	5,019	16.89	
60+	188	1.83	2,147	11.04	2,335	7.86	
Gender							p< 0.001
Male	6,318	61.58	11,028	56.7	17,346	58.38	
Female	3,942	38.42	8,423	43.3	12,365	41.62	
Smoking							p< 0.001
Never	5,789	56.42	10,529	54.13	16,318	54.92	
Ex-smoker	1,316	12.83	1,950	10.03	3,266	10.99	
Current-smoker	3,155	30.75	6,972	35.84	10,127	34.09	
Alcohol							p< 0.001
No	2,106	20.53	4,818	24.77	6,924	23.3	
Moderate	5,252	51.19	9,537	49.03	14,789	49.78	
Risky	2,902	28.28	5,096	26.2	7,998	26.92	
Perceived risk							p< 0.001
No	9,848	95.98	16,591	85.3	26,439	88.99	
Yes	412	4.02	2,860	14.7	3,272	11.01	
Low job control							
No	7,553	73.62	10,610	54.55	18,163	61.13	p< 0.001
Yes	2,707	26.38	8,841	45.45	11,548	38.87	
Financial imbalance							p< 0.001
No	6,077	59.23	8,059	41.43	14,136	47.58	
Yes	4,183	40.77	11,392	58.57	15,575	52.42	
Employment							p< 0.001
Permanent	9,706	94.6	13,558	69.7	23,264	78.3	

Temporary or daily	554	5.4	5,893	30.3	6,447	21.7	
Income							p< 0.001
Higher	7,152	71.22	6,872	35.7	14,024	47.88	
Lower	2,890	28.78	12,376	64.3	15,266	52.12	

P-value was calculated by Chi-square test without survey weighting

Interpretations of total effect, natural direct effect, and natural indirect effect.

Total effects are the effects explained by both occupation and mediators. Natural direct effects are effects explained by occupations,while natural indirect effects are effects explained by mediators (perceived risk at work, long working hours, unstable employment, low job control, financial imbalance, low income).

Perceived risk at work

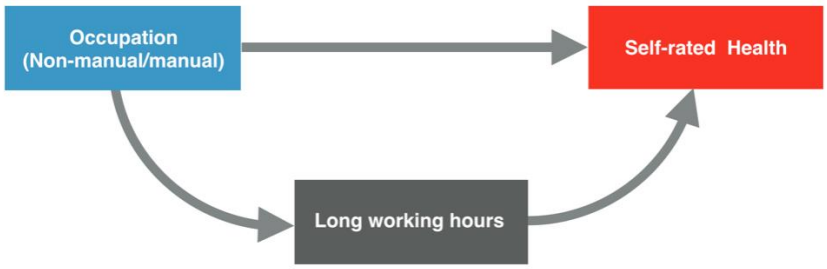

Figure 2.5. Conceptual diagram: mediation of health disparity of perceived risk of safety and health at work between manual works and non-manual workers

The natural direct effect was 1.11 (95%CI: 1.04-1.20) and the natural indirect effect was 1.07 (95%CI: 1.04-1.20).The marginal total effect was 1.19 (95%CI:1.11-1.30). The proportion of total mediated effect was 39% (95%CI: 28-65%)

	Coefficient	95% CI	
Natural direct effect	1.11	1.04	1.20
Natural indirect effect	1.07	1.06	1.09
Marginal total effect	1.19	1.11	1.30

Age, gender, smoking, alcohol consumption, and education were adjusted.

Financial imbalance

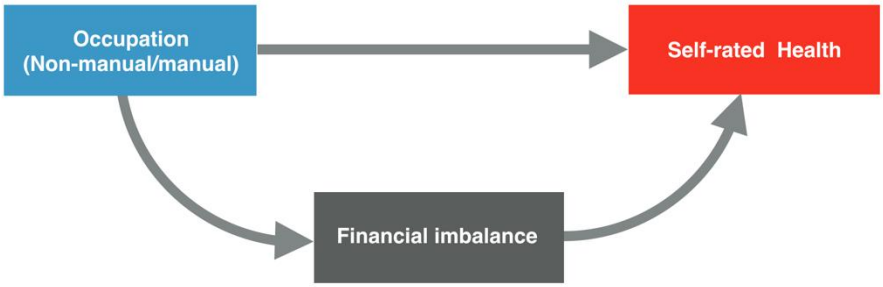

Figure 2.6. Conceptual diagram: mediation of financial imbalance in health disparity between manual works and non-manual workers

The natural direct effect was 1.13 (95%CI: 1.08-1.26) and the natural indirect effect was 1.04 (95%CI: 1.01-1.02). The marginal total effect was 1.18 (95%CI:1.11-1.30). The proportion of total mediated effect was 22% (95%CI:16-39%)

	Coefficient	95% CI	
Natural direct effect	1.13	1.08	1.26
Natural indirect effect	1.04	1.01	1.02
Marginal total effect	1.18	1.10	1.28

Age, gender, smoking, alcohol consumption, and education were adjusted.

Low job control

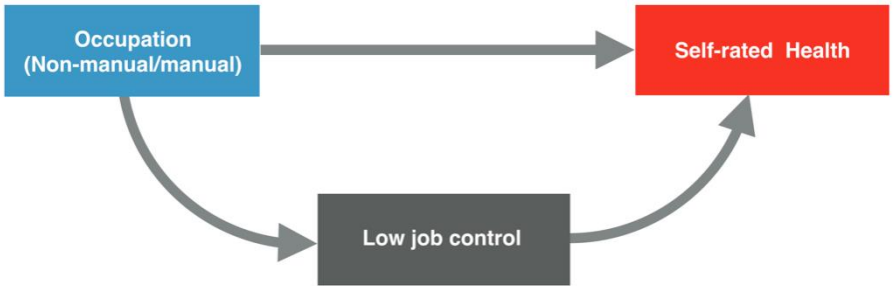

Figure 2.7. Conceptual diagram: mediation of low job control in health disparity between manual works and non-manual workers

The natural direct effect was 1.16 (95%CI: 1.08-1.26) and the natural indirect effect was 1.01 (95%CI: 1.01-1.02). The marginal total effect was 1.18 (95%CI:1.11-1.30). The proportion of total mediated effect was 7% (95%CI:5%-13%).

	Coefficient	95% CI	
Natural direct effect	1.16	1.08	1.26
Natural indirect effect	1.01	1.01	1.02
Marginal total effect	1.18	1.10	1.28

Age, gender, smoking, alcohol consumption, and education were adjusted.

Less than median income

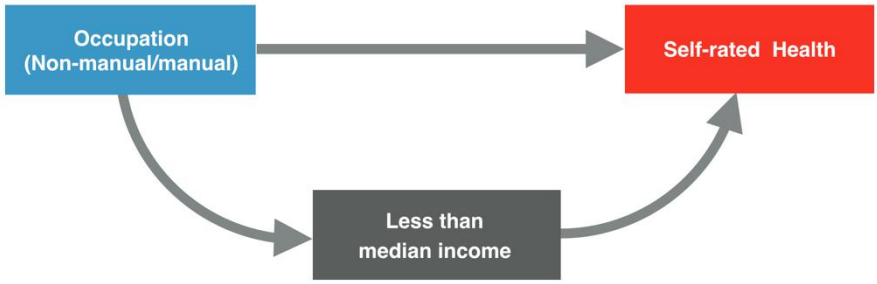

Figure 2.8. Conceptual diagram: mediation of lower income in health disparity between manual works and non-manual workers

The natural direct effect was 1.16 (95%CI: 1.07-1.23) and the natural indirect effect was 1.01 (95%CI: 1.00-1.02). Marginal total effect was 1.17 (95%CI:1.11-1.30). The proportion of total mediated effect was 5% (95%CI:3%-9%).

	Coefficient	95% CI	
Natural direct effect	1.16	1.07	1.23
Natural indirect effect	1.01	1.00	1.02
Marginal total effect	1.17	1.09	1.25

Age, gender, smoking, alcohol consumption, and education were adjusted.

Unstable employment

Figure 2.9. Conceptual diagram: mediation of unstable employment in health disparity between manual works and non-manual workers

The natural direct effect was 1.14 (95%CI: 1.06-1.22) and the natural indirect effect was 1.03 (95%CI: 1.02-1.05). The marginal total effect was 1.18 (95%CI:1.11-1.30). The proportion of the total mediated effect was 20% (95%CI: 15%-34%)

	Coefficient	95% CI	
Natural direct effect	1.14	1.06	1.22
Natural indirect effect	1.03	1.02	1.05
Marginal total effect	1.18	1.10	1.26

Age, gender, smoking, alcohol consumption, and education were adjusted.

Long working hours

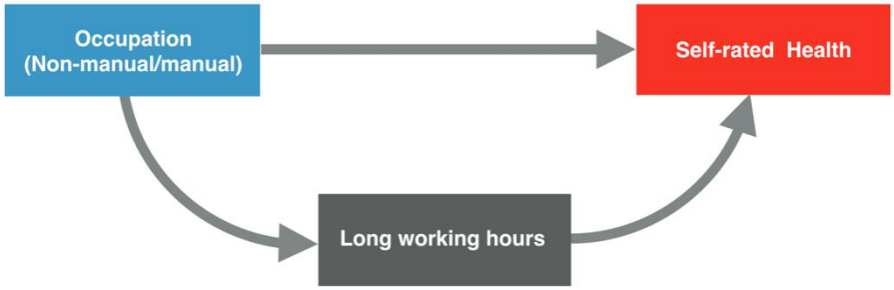

Figure 2.10. Conceptual diagram: mediation of long working hours in health disparity between manual works and non-manual workers

The natural direct effect was 1.12 (95%CI: 1.05-1.20) and the natural indirect effect was 1.05 (95%CI: 1.03-1.07). The marginal total effect was 1.18 (95%CI:1.10-1.26). The proportion of the total mediated effect was 28% (95%CI: 20%-47%).

	Coefficient	95% CI	
Natural direct effect	1.12	1.05	1.20
Natural indirect effect	1.05	1.03	1.07
Marginal total effect	1.18	1.10	1.26

Age, gender, smoking, alcohol consumption, and education were adjusted.

Discussion

Mediation analysis could directly estimate the effect sizes of the mediating pathway. The health gap among different occupations has already been sufficiently explored.(42) Health inequality among different occupations could be explained by the gap of available resources due to income inequalities, a psycho-social stressor such as low job control, exposure to occupational hazards, and unstable employment status. However, few studies have directly compared effect sizes of mediations by using mediation analysis. One advantage of this study was comparing the effect size of possible mediation paths which could contribute to health disparity between manual and non-manual workers.

Even though all mediating variables significantly contributed to the health gap, among the possible mediation paths leading to a health gap between manual workers and non-manual workers, the perceived risk of safety and health at work had a larger effect size than financial imbalance, unstable employment, lower than median income, low job control, and long working hours. This result suggests that perceived risk at work might contribute more to health inequality than other mediating variables among Korean employees. This result implied general working conditions, including workplace safety, might be one of the most important determinants of health, particularly for individuals of working age.

As with perceived risk at work, long working hours contributed to the health gap between manual and non-manual employees. This result might reflect a situation in which blue-collar workers and service and sales workers have to extend their working hours to compensate for a low hourly wage. In Korea, long working hours might be an important pathway that can generate health inequality.

The majority of previous studies on health inequality among different socioeconomic positions based on occupation focused on psychosocial working conditions such as job strain, low job control, effort-reward imbalance, and organizational justice.(7, 21, 84, 85) This attention to psychosocial working conditions might reflect the reality of working in the complex organization of modern society. However, a significant proportion of the working population has been yet working dangerous working circumstance vulnerable to accidents. A significant proportion of the working population is exposed to various occupational hazards.(86) To reduce the health gap between manual workers and non-manual workers, not only psychosocial working conditions but also other general working conditions including workplace safety should be improved. Also, working conditions need to be improved under the principle of proportionate universalism.(74)

Interestingly, as the mediator of the effect size (the proportion of the mediated total effect), financial imbalance was greater than the effect size of lower income on the health gap between manual workers and non-manual workers. Self-rated health is a subjective measurement of health. When people could not make ends meet or when resources were insufficient for their needs, they might feel the situation is more stressful simply having a low paid job in itself. The result of this study implies that financial imbalance might be more important than income per se. Therefore, when it comes to self-rated health, to reduce the health gap resources need to be re-allocated on the basis of people's needs rather than income in itself.

The results of this chapter have several limitations. First, this study was a cross-sectional study which might be prone to reverse causation. Second, self-rated health is a subjective measurement of health. There could be disparities between subjective health and objective health. Third, perceived risk of safety and health at work is a subjective measurement of general working conditions, although the perceived risk of safety and health at work is a comprehensive assessment of general working conditions. There could be a discrepancy between subjective and objective assessments of working conditions, and this discrepancy could be the source of an information bias. Last, this chapter could not

utilize survey weighting because the user-made commands “paramed” and “medeff” do not support survey-weighted analysis. Thus, this chapter could not take full advantage of theThird Korean Working Conditions Survey which could be a national representative sample.

Conclusion

This chapter demonstrated that the health gap between non-manual worker and manual workers could be mediated by occupational hazard exposures and material resources such as income and financial balance. Considering the proportion mediated, perceived risk at work and long working hours had larger proportions. Improving working conditions related to safety and health and reducing long working hours could be important measurements in reducing health inequality in Korean society.

Chapter 3. The influence of combined exposure to perceived risk at work and unstable employments on self-rated health: A comparison between Korea and European countries

Introduction

Korea still suffers from traditional industrial accidents or acute industrial intoxication.(87) Although Korea has legal provisions prohibiting the subcontracting and outsourcing of hazardous work, more workers under unstable employment might have been involved with dangerous and harmful jobs.(88) According to a brief report on fatal industrial accidents in the shipbuildingindustry, the majority of fatal accidents occurred among workers with unstable employment.(89) Although there is little systematic research on the hazard exposure gap between different employment status,(90) short reports in newspapers on fatal injury occurrence among at-risk workers might reflect the inequality between different occupations and employment status.

The gap of exposure to hazardous conditions between regular workers and temporary workers in the same occupations brings up an important ethical issue. It is a deviation from the principle of equity and requires social efforts such as strict legal regulations on the subcontracting or

outsourcing of hazardous work. Previous studies reported harmful effects of precarious or unstable employment on health.(91-93) However, the combined effects of unstable employment and perceived risk of safety and health at work have rarely been studied. If working under unstable employment and dangerous working conditions simultaneously are more harmful due to the interaction between the two concurrent exposures, more social efforts should be made to improve conditions for these workers. It is also necessary to examine whether the interaction is a unique phenomenon of Korea, where workers have been unfairly treated, or if there a similar interaction exists in other industrialized countries.

A comparative study on health equality between countries might give opportunities for insight into this question.(94, 95) A wider social structure, including the welfare system of each country and the relationship between employers and employees, might modify the influence of hazardous working conditions.(96, 97)

Therefore, the aim of this chapter is to examine whether there is a difference in the combined effect of unstable employment and perceived risk at work on self-rated health between Korea and European countries.

Method

Study Subjects

The study population of this chapter was employees in the third Korean Working Conditions Survey (KWCS) undertaken in 2011. The survey was conducted by trained interviewers through face-to-face interviews under the leadership of the Korea Occupational Safety and Health Agency (KOSHA).

The KWCS assessed the distribution of work-related risk factors for making occupational safety policy. The contents of the questionnaire were comparable to the European Working Conditions Survey. The KWCS used a representative sample, only including the economically active population over 15 years of age in South Korea.(75)

Total sample size of the third Korean Working Conditions Survey was 50,033 (unweighted sample size=50,032), and the sample size of employees was 35,903 (unweighted sample size=29,711).

Sampling and Survey weighting

The survey sample was taken from the population and housing census conducted in 2010. To be a representative sample of the economically active population, students, housewives, the unemployed, retired

persons, and students were excluded. The sampling method employed a multistage stratified approach utilizing the probability proportional to size. Census districts were selected using probability which wasproportional to thesizeof systematic sampling reflecting the number of households in the census district. Then, ten households were chosen at random within the selected census district. Finally, one eligible person was interviewed in the selected household.

The survey weighting was calculated using the information on distribution by region, locality, size, gender, age, and occupation. Also, the response rate of interviewees was taken into account to calculate the survey weighting.

Study Variables

Sociodemographic and behavioral characteristics

Information on age, sex, educationalattaiment, income, smoking habits, and alcohol drinking was collected through questionnaires. Age was categorized as 15–29, 30–39, 40–49, 50-59, and 60 or more years of age. Education level was categorized as middle school (lower secondary education) or less, high school (higher secondary education), college, and university or more (post-secondary education, tertiary education, or more). Monthly income was divided into fourgroups by quartile. Alcohol

consumption was categorized as none, moderate, or risky. Risky alcohol consumption was defined as drinking more than seven units of alcohol at one time (binge drinking) or drinking more than 14 units of alcohol per week. Smoking was categorized as non-smokers, ex-smokers, or current smokers.

Occupation and employment

The question on occupations in the original questionnaire included eight categories which were professional, management, office, sales, service, skilled, semi-skilled, non-skilled, fishery, and farming. For analysis, the eight categories were combined into four categories which were management and professional, office worker, salesand service, or manual (skilled, semi-skilled, non-skilled, and farming and fishery). Employment status was defined as regular, temporary, or daily. In the analysis, employment status was divided into two categories (regular vs. temporary or daily) in Korea. Employment status was defined as regular, fixed term, and temporary, and employment status was divided into two categories (regular vs. fixed term or temporary) in EU countries.

Perceived risk of safety or health at work is assessed by the question "Do you think your health or safety is at risk because of your work?".

“Yes” was regarded as a perceived risk at work, and “no” was regarded as no perceived risk on safety or health at work.

Regarding information on safety and health, “Very well informed” or “Well informed” was regarded as informed. “Not very well informed” or “Not at all well informed” was regarded as poorly informed.

Statistical Analysis

Proportions were calculated by occupation and employment statuswith survey weighting (svy:tab). Statistical analysis was undertaken using Stata (Version 13.1).

The relative excess risk due to interaction (RERI) and ratios of odds ratios (ORs)(47)

The relative excess risk due to interaction (RERI) is calculated to estimate the interaction between joint exposures based on additive scales.

$$RERI = OR_{\text{combined exposure to perceived risk at work and unstable employment}} - OR_{\text{exposure to only perceived risk at work}} - OR_{\text{exposure to only unstable employment}} + 1$$

A RERI larger than 0 indicates supra-additivity.

Odds ratios (ORs) are calculated to estimate the interaction between combined exposures based on multiplicative scales.

$OR_{\text{combined exposure to perceived risk at work and unstable employment}}$/

($OR_{\text{exposure to only perceived risk at work}} \times OR_{\text{exposure to only unstable employment}}$)

Ratios larger than 1 indicate that the joint effect of two exposures is larger than the product of effects of the two separate exposures.

Results

Characteristics of study population

Table 1. showed the general characteristics of Korean employees. The percent of female employees was 41%. Sixty percent of participants were in their thirties and forties. Thirty-four percent of participants were current smokers, and 28 percent of participants were risky alcohol consumers. More than half of participants finished college and university. The percent of sale and service works was 27, and the percent of manual works was 34. In term of employment status, 20 percent of employees were temporary and daily workers.

Table 3.1. The characteristics of study population (Korean employees)

	N	Proportion
Gender		
Female	14618	0.41

Male	21286	0.59
Age		
15-29	5589	0.16
30-39	10972	0.31
40-49	10488	0.29
50-59	6058	0.17
60+	2796	0.08
Smoking		
No	19614	0.55
Ex	4037	0.11
Current	12252	0.34
Alcohol consumption		
No	8216	0.23
Moderate	17526	0.49
Risky	10162	0.28
Education		
Middle school <	2643	0.08
High School	13155	0.38
College	6352	0.18
University	12497	0.36
Occupational		
Professional & managerial	3095	0.09
Office or clerical	10682	0.3
Sales & Service	9846	0.27
Manual	12281	0.34
Employment		
Regular	28543	0.8
Temporary	5078	0.14
Daily	2283	0.06
Income		
Lowest	7944	0.23
Low middle	9223	0.26
High middle	9164	0.26
Highest	8844	0.25

Table 2. demonstrated the characteristics of EU employees. The

proportion of female employees was 46%. Fifty percent of the study population was in their thirties and forties. EWCS did not investigate smoking and alcohol consumption. More than half of participants finished post-secondary education or tertiary education. The proportion of sale and service workers was 17 percent, and the proportion of manual workers was 33 percent. In term of employment status, 22 percent of employees was under fixed-term or temporary employment.

Table 3.2. The characteristics of study population (EU employees)

	N	Proportion
Gender		
Female	16234	0.46
Male	18844	0.54
Age		
15-29	8086	0.23
30-39	9361	0.27
40-49	9054	0.26
50-59	7053	0.20
60+	1524	0.04
Education		
Lower secondary or less	7872	0.22
Upper secondary	14400	0.41
Post-secondary but not tertiary	1541	0.04
Tertiary education or more	11176	0.32
Occupation		
Professional & managerial	8028	0.23
Clerical and technician	9238	0.27
Sales & Service	5977	0.17
Manual	11540	0.33
Employment		
Indefinite	26873	0.78

Fixed term	4032	0.12
Temporary	3466	0.10
Income		
Lowest	5821	0.24
Low middle	6281	0.25
High middle	6557	0.27
Highest	6023	0.24

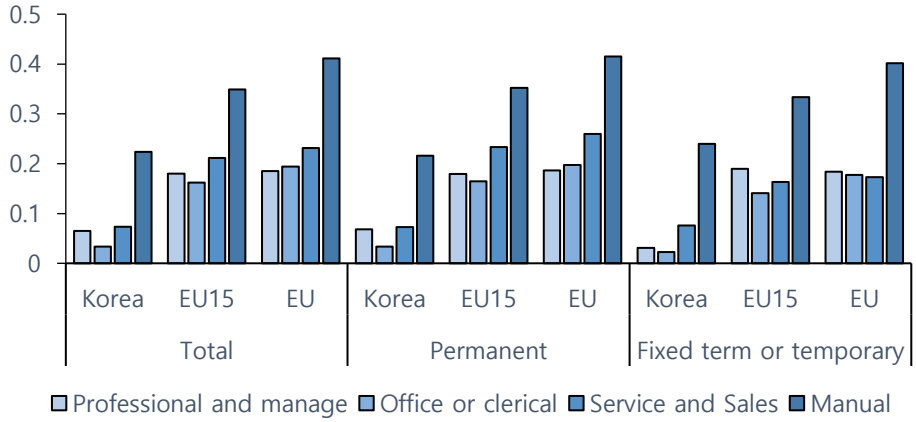

Figure 3.1. The proportions of perceived risk on safety and health at work by occupations and employment status

Interaction between the perceived risk of safety and health at work and employments status on self-rated health in Korea and EU countries

In Korea, the perceived risk of safety or health at work (OR: 2.00; 95%CI: 1.80-2.20) and unstable employment (OR: 1.18; 95%CI: 1.09-1.28) both incresed the risk of poor self-rated health. Furthermore, there was an interaction between both the perceived risk of safety or health at work

and employment status on an additive scale (RERI: 1.03; 95%CI: 0.48-1.58) and on a multiplicative scale (ratio of ORs: 1.36; 95%CI: 1.11-1.66).

In EU countries, only the perceived risk of safety or health (OR: 3.20; 95%CI: 2.93-3.49) was linked with an increased risk of poor self-rated health, but unstable employment (OR1.04, 95%CI:0.93-1.17) was not significantly associated with poor self-rated health. A significant interaction was not found on an additive scale (RERI: 0.18; 95%CI:-0.36-0.71), nor on a multiplicative scale (ratio of ORs:1.02, 95%CI:0.85-1.24).

Table 3.3. Effect of the perceived risk at work and employments status on self-rated health among Korean employees*

	Perceived risk at work (-)	Perceive risk at work (+)	OR for perceived risk (-) vs. perceived risk (+) within strata of employment
	OR(95% CI):p	OR(95% CI):p	OR(95% CI):p
Stable employment	Reference	2.00(1.80-2.22):p<0.001	2.00(1.80-2.20):p<0.001
Unstable employment	1.18(1.09-1.28):p<0.001	3..22(2.72-3.81):p<0.001	2.72(2.29-3.24):p<0.000
OR for stable employment vs unstable employment within strata of long perceived risk at work	1.18(1.09-1.28):p<0.001	1.60(1.33-1.93):p<0.001	
Measure of interaction on additive scale: RERI	1.03(0.48-1.58):p<0.001		
Measure of interaction on multiplicative scale: ratio of ORs	1.36(1.11-1.66):p=0.003		

CI: confidence interval, *:age, gender, income, education, occupations, smoking, and alcohol consumption were adjusted in the model

Table 3.4. Effect of the perceived risk and employments status on self-rated health among employees in EU countries*

	Perceived risk at work (-)	Perceive risk at work (+)	OR for perceived risk (-) vs perceived risk (+) within strata of employment
	OR (95% CI):p	OR(95% CI):p	OR(95% CI):p
Stable employment	reference	3.20(2.93-3.49):p<0.001	3.20(2.93-3.49):p<0.001
Unstable employment	1.04(0.93-1.17):p=0.490	3.41(2.93-3.98):p<0.001	3.28(2.75-3.90):p<0.000
OR for stable employment (0) vs unstable employment (1) within strata of perceiver risk at work	1.04(0.93-1.17):p=0.490	1.07(0.91-1.25):p<0.405	
Measure of interaction on additive scale: RERI	0.18(-0.36-0.71):p=0.519		
Measure of interaction on multiplicative scale: ratio of ORs	1.02(0.85-1.24):p=0.802		

CI: confidence interval, *:age, gender, income, education, and occupations were adjusted in the model

Discussion

Occupational hazard exposures across occupations

In both Korea and EU countries, gradients in occupational hazard exposures were observed (Korea tables 2-5 in chapter 1; EU appendix tables 1-4; EU15 appendix tables 6-9). In the majority of occupational hazards, the proportions of exposure for service and sales workers and manual workers were higher than those for professional and managerial workers and office workers. The highest proportion of employees exposed to occupational hazards was among manual workers.

The gap between different employment statuses in occupational hazard exposures

In general, occupations were a more important determinant of occupational hazard exposures than employments status. However, in some types of exposures, there were gaps between stable employment and unstable employment. The observed gaps between different employment statuses were larger in Korea than in EU countries (Korea tables 2-5 in chapter 1; EU appendix tables 1-4). These exposure gaps might imply that Korean workers under unstable employment had to bear the heavier burden of hazardous exposures and reflect the reality that some workplaces did not follow regulations including the prohibition of

subcontracting or outsourcing of the harmful tasks.

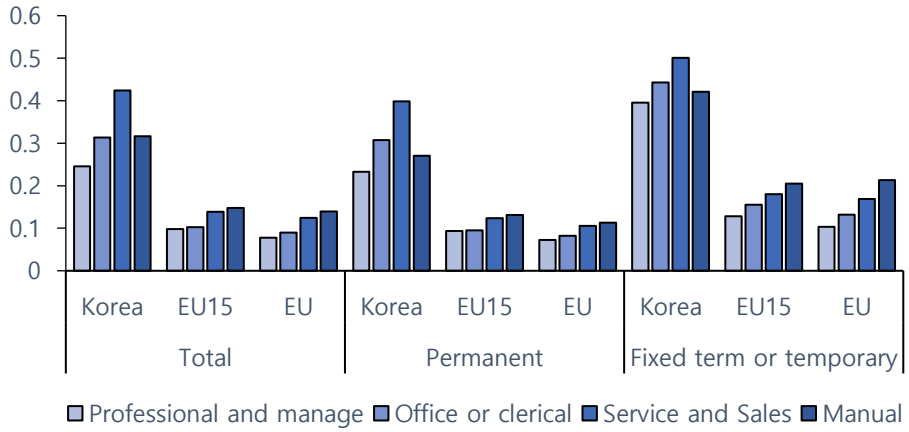

Figure 3.2. The proportions of poorly provided information on safety and health at work by occupations and employment status

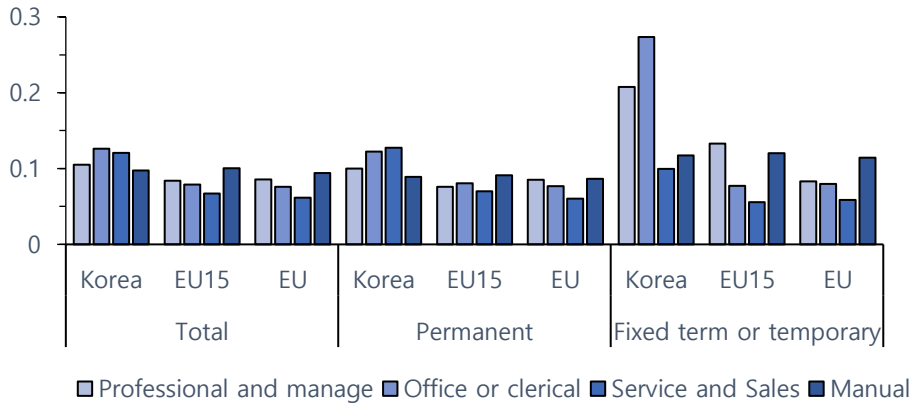

Figure 3.3. The proportions of workers not using PPEs while PPEs is required by occupation and employment status

PPE use and providing information on safety and health

In Korea, regardless of occupation (except for service and sale workers), a higher proportion of workers under unstable employments did not use PPE when PPE was necessary, whereas in EU countries this tendency was not found except for in manual worker. The gaps on providing information on safety and health between different employment statuses were observed both in Korea and EU countries; the gap was larger in Korea than in EU countries. PPEs and providing information is a primitive measurement for safety and health in the workplace. The gaps between different employment statuses suggest poor management in safety and health among at-risk workers both in European countries and Korea. Korean workers under unstable employment might have more severe problems with safety and health in the workplace compared to EU countries.

Interpretation of interaction analysis between perceived risk at work and employments status.

In EU countries, perceived risk increased the risk of poor self-rated health. However, aninteractionbetween perceived risk at work and unstable emplyment was not found. In Korea, both perceived risk and employment status were linked with increased proportions of poor self-

rated health, and an interaction between perceived risk and employment status was observed. Although the cause of the interaction could be explored through a more detailed investigation of occupational hazard exposure and other social determinants of health, the interaction observed in Korea might be explained by two possible paths. First, there was a possibility that at-risk workers were working under more dangerous and unhealthy working conditions that the quantitative analysis could not capture. Another possible path is that precarious workers were more seriously affected by health problems due to other harmful social circumstances, such as wage disparities and other discriminations. If the first path was the cause of interaction, working conditions for precarious workers should be improved. If the second path was the cause of interaction, inequalities such as the wage gap between standard workers and at-risk workers should be reduced. Future studies should explore working conditions of workers under unstable employment to find the causes of interaction between unstable employment and perceived risk at work.

Conclusion

To reduce the gap generated by the interaction between perceived risk at work and unstable employment, harmful working conditions, which

precarious workers have to bear, should be improved, and other inequalities including wage gaps between different employment statuses also need to be reduced.

Chapter 4. The combined effect of long working hours and low job control on self-rated health: an interaction analysis (This chapter was accepted by JOEM in Dec 2017 and will be published)

Introduction

Despite a decreasing trend in working hours, Korea exhibits one of the longest average working hours in comparison to other countries.(98)There are several reasons underlying the prevalent long working hours in Korea.(99) First, Korean society has encouraged long working hours for better economic achievement. Many employees sacrifice their evenings to achieve goals employers or supervisors set, and employees have accepted this. Second, the legal minimum wage is too low to maintain healthy lives. Employees earning near minimal wages working 40 hours a week cannot meet basic needs. For this reason, many employees voluntarily extend working hours to earn more to support their cost of living. Third, as there is widespread job insecurity and poor social protection for the unemployed in Korean society, even those earning a decent income in large companies want to make as much extra income as possible.(100)

Long working hours might contribute to the rapid economic growth of South Korea, but the negative effects of long working hours, including

various health problems, remain a widespread social concern in Korea. An increasing number of studies have reported the association between long working hours and negative health outcomes, including sleep deprivation, depression and anxiety disorders, and cardiovascular diseases, especially stroke.(101-109) The relative risk of stroke is 1.33 for those working 55 hours or more compared to those working 36-40 hours (standard working hours) .

In addition to long working hours, social psychological stressors in the workplace may also contribute to poor health.(110) Low job control is one of the most well-known occupational stressors. In the job strain model developed by Karasek and Theorell, high job strain is defined as the combination of low decision latitude in a task and high psychological demands.(111) High job strain and low job control (low decision latitude, which is one component of job strain) are risk factors for cardiovascular disease and mental health problems such as depression.(7, 19, 23, 111, 112)

Long working hours are linked with insufficient recovery due to reduced sleep hours and rest times. (113, 114) Furthermore, long working hours are associated with extended exposure to hazardous working conditions. For this reason, the influence of long working hours should be investigated in the context of other working conditions, including

occupational stressors. Recently, several studies have explored the interaction between long working hours and other work stressors. A study in Japan reported the harmful effects of overtime work under low job control (115, 116) while a study in Korea showed that long working hours under precarious employment can lead to more severe mental health problems.(116) However, to the best of our knowledge, few studies have explored these interactions as the main purpose of the study, given that epidemiologists have recently suggested the method for interaction analysis.(47) If greater health problems arise due to interactions between long working hours and low job control, an important point for intervention may be to reduce the working hours of workers who are simultaneously exposed to long working hours and low job control.

Therefore, the purpose of this study was to analyze the interaction between long working hours and low job control, and their effect on employees' health with the sample from the third Korean Working Condition Survey (KWCS).

Methods

Study Subjects

This study used the sample from the third Korean Working Conditions

Survey (KWCS) carried out in 2011 by the Korea Occupational Safety and Health Agency (KOSHA). The KWCS is conducted to assess the distribution of risk factors related to working conditions for occupational safety and health policy and is comparable to the European Working Conditions Survey. The KWCS provides a nationally representative sample, including the economically active population over 15 years of age. To exclude the influence of underemployment, we included only employees who worked 36 hours or more per week. The total sample size of the 3rd Korean working condition survey was 50,033 (unweighted sample size=50,032). The sample size of employees was 35,903 (unweighted sample size=29,711), and the sample size of employees with weekly working hours of more than 35 hours was 32,857 (unweighted sample size=27,039).

Sampling, the Questionnaire, and Survey Weighting

The survey, which involved face-to-face interviews, was conducted by trained interviewers in 2011. The survey sample was drawn from the population and housing census conducted in 2010. In order to ensure a representative sample of the economically active population aged over 15 years, unemployed people, retired persons, housewives, and full-time students were excluded from the survey sample.

Sampling was based on a two-stage stratified approach using the probability-proportional-to-size method, by which census districts were selected based on the number of households in the census district. Then, 10 households were randomly selected within each selected census district. Finally, one eligible person from each selected household was interviewed. When more than one eligible person was identified in a selected household, interviewee selection was randomized using the randomization program on portable computers.

Survey weighting was conducted for the representativeness of the entire economically active population of Korea and was estimated by distribution, region, locality, size, sex, age, and occupation. The response rate of households was considered as well.

Ethical Considerations

The need for ethical review and informed consent was waived by the institutional review board of Hallym University Hospital.

Study Variables

Questionnaire of the 3rd KWCS

All study variables were assessed by the questionnaire. For

comparability, the questionnaire was developed based on a translation of the questionnaire for the European Working Conditions Survey. Although validation was not conducted for the 3rd KWCS, the validity and reliability of 2nd KWCS have been reported.[26] Regarding working conditions, the 2nd and 3rd KWCSs employed almost the same questions.

Sociodemographic and behavioral characteristics

Information about age, sex, education level, income, smoking, and alcohol consumption was collected via interviews. Age was categorized as 15–29, 30–44, 45–55, and 60 or more years. Education level was categorized as middle school (lower secondary education) or less, high school (higher secondary education), or college or more (post-secondary education, tertiary education, or more). Monthly income was divided into quartiles. Alcohol consumption was categorized as none, moderate, or risky. Risky alcohol consumption was defined as drinking more than 7 units of alcohol at one time (binge drinking) or drinking more than 14 units of alcohol per week. Smoking was categorized as non-smokers, ex-smokers, or current smokers.

Occupational characteristics

Occupations was categorized as management and professional, office work, sales and service, or manual. A small number of employees in farming and fishery (weighted count: 86) were regarded as manual. Employment status was categorized as regular, temporary, or daily. (Daily labor refers to work based on a daily contract; in Korea, there is a relatively a high proportion of daily workers in construction. In general, daily workers face a very unstable employment status.) Shift work was divided into two groups based on the response to the item, “I perform shift work.”

Working hours and low job control

Working hours were calculated by adding the average number of weekly working hours of the main paid job and the second paid job. Working hours were divided into two categories: 36–52 hours per week was considered standard, and more than 52 hours per week was considered long. The legal number of working hours per week in Korea is 40, and 52 hours is the maximum allowed when employees agree to work extended hours. Low job control was defined based on the response to the questionnaire item, “You can influence decisions that are important for your work.” Answers of “rarely” or “never” were regarded as low job control, while “always”, “most of the time”, or “sometimes” were regarded

as high job control.

Self-rated health

Health was assessed based on the response to the subjective question, “How is your health in general?” “Very poor”, “poor”, or “fair” were regarded as self-rated poor health, while “very good” or “good” were regarded as good health.

Other health variables

The 3rd KWCS considered medical histories of hypertension and obesity using the questions, “Have you been diagnosed with hypertension by a physician?” and “Have you been diagnosed with obesity by a physician?” However, a medical history of other chronic diseases was not investigated.

Statistical Analysis

A chi-square test with survey weighting (svy:tab) was used to estimate differences among groups based on long working hours and job control. To estimate odds ratios (ORs), multiple survey logistic analysis was employed (svy:logistic [for adjusted ORs]). In the model, age, sex, educational level, income, occupation, smoking, and alcohol

consumption were included as potential confounders.

For the interaction analysis, we initially employed multiple survey logistic analysis including all other potential confounding variables and the product term between long working hours and low job control in the model. Then, we estimated the combined effect of long working hours and low job control using the linear combination (lincom) command. Finally, we conducted interaction analysis between long working hours and low job control using “linear combination of coefficients” (lincom) and “nonlinear combination of coefficients” (nlcom). RERI and confidence intervals were estimated using the nonlinear combination of coefficients, and the ratio of ORs and confidence intervals were estimated using the linear combination of coefficients. The commands “lincom” and “nlcom” are post-estimation commands for estimating the combined effects of multiple variables after regression-based models. These commands can perform interaction analysis based on both additive and multiplicative scales, and can estimate confidence intervals. All statistical analyses were conducted using Stata version 13.1 (StataCorp, Texas, USA).

Relative excess risk due to interaction (RERI) and ratios of odds ratios (ORs)

RERI can be used to estimate the interaction between two combined

exposures based on an additive scale, calculated using the following formula:

$RERI = OR_{\text{combined exposure to long working hours and low job control}} - OR_{\text{exposure to only long working hours}} - OR_{\text{exposure to only low job control}} + 1.$

RERI greater than 0 indicates supra-additivity with positive interaction on the additive scale.

Ratios of ORs estimate the interaction between two combined exposures based on a multiplicative scale and are calculated using the following formula:

$OR_{\text{combined exposure to long working hours and low job control}} /$

$(OR_{\text{exposure to only long working hours}} \times OR_{\text{exposure to only low job control}})$.

A ratio greater than 1 indicates that the combined effect of two exposures is greater than the product of the estimated effect of two separate exposures.

Results

Working Hours Based on Sociodemographic and Work Characteristics

A significant proportion of employees in Korea (0.29) worked more than 52 hours per week (Table 1). Men tended to work longer hours than women, and older employees had the highest proportion of long working hours. Regarding socioeconomic status (SES), employees with the lowest education level, with low and middle income, in the service and

sales sector, and with temporary contracts had the highest proportion of long working hours. Regarding occupation, the proportion of service and sales workers who worked more than 52 hours per week was 0.42. Regarding work characteristics, shift workers and employees with low job control had a higher proportion of long working hours. Furthermore, unfavorable health behaviors were related to long working hours. Additionally, the proportion of current smokers who worked more than 52 hours per week was 0.34, and the proportion of risky alcohol consumers who worked more than 52 hours per week was 0.33.

Table 4.1. Characteristics of the study population by working hours

	Total		Long working hours (-)		Long working hours (+)		
	N	Proportion	N	Proportion	N	Proportion	p
Gender							< 0.0001
Female	12667	0.39	9392	0.74	3265	0.26	
Male	20200	0.61	13898	0.69	6302	0.31	
Age							< 0.0001
15-29	4972	0.15	3361	0.68	1612	0.32	
30-44	15841	0.48	11619	0.73	4221	0.27	
45-59	10003	0.30	7087	0.71	2916	0.29	
60-	2041	0.06	1224	0.60	818	0.40	
Smoker							< 0.0001
No	17370	0.52	13000	0.75	4370	0.25	
Ex	3789	0.11	2608	0.69	1181	0.31	
Current	11698	0.35	7682	0.66	4016	0.34	
Alcohol consumption							< 0.0001
No	6857	0.21	5116	0.75	1741	0.25	
Moderate	16337	0.50	11669	0.71	4668	0.29	
Risky	9663	0.29	6505	0.67	3158	0.33	
Education							< 0.0001
Middle school	2887	0.09	1710	0.59	1178	0.41	
High school	11904	0.36	7203	0.61	4701	0.39	
College or more	18064	0.55	14378	0.80	3687	0.20	
Occupation							< 0.0001
Professional &managerial	2820	0.08	2442	0.87	379	0.13	

Office	10440	0.32	9187	0.88	1253	0.12	
Sales & service	8779	0.27	5049	0.58	3731	0.42	
Manual	10817	0.33	6613	0.61	4204	0.39	
Employment							< 0.0001
Regular	27635	0.84	20112	0.73	7523	0.27	
Temporary	3788	0.12	2218	0.59	1570	0.41	
Daily	1434	0.04	960	0.67	474	0.33	
Income							< 0.0001
Lowest	5536	0.17	3736	0.67	1801	0.33	
Low middle	8918	0.28	5591	0.63	3328	0.37	
High middle	9017	0.28	6356	0.70	2662	0.30	
Highest	8717	0.27	7070	0.81	1648	0.19	
Shift work							< 0.0001
No	29706	0.90	21568	0.73	8139	0.27	
Yes	3151	0.10	1723	0.55	1429	0.45	
Job control							< 0.0001
High job control	20830	0.63	15109	0.73	5722	0.27	
Low job control	12027	0.37	8181	0.68	3846	0.32	

*p-values estimated by survey-weighted chi-square test.
Long working hours (-): within the legal limit: 36 ≤ working hours ≤ 52.
Long working hours (+): more than the legal limit: 52 < working hours.

Proportion of Poor Self-Rated Health, and Factors Related to Poor Self-Rated Health

The proportion of poor self-rated health was 0.28 (9,276/32,857), and the proportion of low job control was 0.37 (12,027/32,857).

Table 2 shows the factors associated with poor self-rated health without considering the interaction between long working hours and low job control. Long working hours (OR: 1.30, 95% confidence interval [CI]: 1.22–1.40) and low job control (OR: 1.09, 95% CI: 1.02–1.16) were associated with lower self-rated health. Temporary (OR: 1.20, 95% CI: 1.10–1.32) or daily (OR: 1.65, 95% CI: 1.43–1.90) employment status had lower self-rated health relative to regular employment. Regarding education level, those with a middle school education or less (OR: 1.39, 95% CI: 1.22–1.58) had a higher risk of poor self-rated health than college graduates. Long working hours, low job control, temporary employment, daily employment, low educational level (middle school or less), and moderate alcohol consumption were significantly statistically associated with poor self-rated health. However, there were no statistically significant associations between occupation, income, smoking, or sex and poor self-rated health.

Table 4.2. Factors associated with poor self-rated health by multiple survey logistic analysis

	OR	95% CI		p
Working hours				
≤ 52 hours > 35	reference			
> 52 hours	1.30	1.22	1.40	< 0.001
Job control				
High job control	reference			
Low job control	1.09	1.02	1.16	0.007
Occupation				
Professional & managerial	reference			
Office	0.97	0.85	1.10	0.619
Sales & service	0.99	0.87	1.13	0.900
Manual	1.08	0.94	1.24	0.259
Employment				
Regular	reference			
Temporary	1.20	1.10	1.32	< 0.001
Daily	1.65	1.43	1.90	< 0.001
Shift work				
No	reference			
Yes	1.01	0.91	1.12	0.852
Income				
Highest	reference			
High middle	1.01	0.92	1.10	0.825
Low middle	1.05	0.95	1.16	0.336
Lowest	1.07	0.95	1.20	0.285
Education				
College or more	reference			
High school	1.03	0.96	1.11	0.417
Middle school or less	1.39	1.22	1.58	< 0.001
Smoker				
No	reference			
Ex-	0.91	0.81	1.01	0.082
Current	0.96	0.88	1.04	0.291
Alcohol consumption				
No	reference			
Moderate	1.11	1.02	1.20	0.011
Risky	1.01	0.92	1.11	0.793

Sex				
Male	reference			
Female	1.03	0.95	1.13	0.432
Age (years)				
15–29	reference			
30–44	1.45	1.31	1.59	< 0.001
45–59	2.03	1.83	2.26	< 0.001
60+	2.61	2.24	3.05	< 0.001

Interaction Analysis using Post-Estimation Command (Linear Combination of Coefficients and Nonlinear Combination of Coefficients)

When employees worked long hours without low decision latitude, the OR for self-rated health was 1.24 (95% CI: 1.13–1.35). The OR for poor self-rated health was 1.04 (95% CI: 0.97–1.13) when employees worked under low job control without long working hours. Moreover, when employees were simultaneously exposed to long working hours and low job control, the OR for poor self-rated health was 1.47 (95% CI: 1.33–1.62). RERI (indicating additive interaction) was 0.18 (95% CI: 0.02–0.34). The ratio of ORs (indicating multiplicative interaction) was 1.13 (95% CI: 0.99–1.28), with a *p*-value of 0.06 (Table 3).

Table4.3. Effect of Long Working Hours and Low Job Control on Self-Rated Health*

	Long working hours (-) OR(95% CI):p	Long working hours (+) OR(95% CI):p	OR for long working hours (0) vs. long working hours (1) within strata of job control OR(95% CI):p
Low job control (-)	reference	1.24(1.13-1.35):p <0.001	1.24(1.13-1.35):p <0.001
Low job control (+)	1.04(0.97-1.13):p=0.252	1.47(1.33-1.62):p <0.001	1.40(1.27-1.55):p<0.000
OR for low job control (0) vs low job control (1) within strata of long working hours	1.04(0.97-1.13):p=0.252	1.18(1.06-1.31):p<0.001	
Measure of interaction on additive scale: RERI	0.18(0.02-0.34):p=0.027		
Measure of interaction on multiplicative scale: ratio of ORs	1.13(0.99-1.28):p=0.061		

CI: Confidence Interval* The model was adjustedwith age, sex, education, income, occupation, smoking and alcohol consumption. ORs were estimated by using linear combination command and non-linear combination command after survey logistic analysis.
Long working hours (-): within legal working our limitation: 36 =< working hours =< 52
Long working hours (+): more than legal working our limitation: 52 < working hours

Additional Analysis Including Hypertension and Obesity in the Model

In Table 3, age, sex, income, education, occupation, income, smoking, and alcohol consumption are included as potential confounders. A medical history of hypertension or obesity was additionally included in the model. Although hypertension (OR: 1.88; 95% CI: 1.63–2.17) and obesity (OR: 1.97; 95% CI: 1.62–2.42) increased the risk of poor self-rated health, the statistical significance of long working hours and low job control on self-rated health did not change. When hypertension and obesity were included in the model, the OR for poor self-rated health with long working hours was 1.24 (95% CI: 1.13–1.35), while the OR for poor self-rated health with low job control was 1.05 (95% CI: 0.97–1.14). Further, RERI was 0.19 (95% CI: 0.03–0.35) and the ratio of ORs was 1.14 (95% CI: 0.99–1.29) when hypertension and obesity were included.

Discussion

Interaction between Long Working Hours and Low Job Control

Longer working hours can result in longer exposure to harmful working conditions. The interaction between long working hours and job stressors could have a synergistic detrimental effect on health. Measuring interactions on an additive scale is the most appropriate way

to assess interaction in modern epidemiologic studies. (45, 46) The current study investigated the interaction between long working hours and low job control. RERI due to combined exposure to long working hours and low job control was greater than 0, indicating that the effect of joint exposure was greater than the additive effect of both exposures. Thus, although the size of the effect was moderate, there was synergism between concurrent exposure to long working hours and low job control.

Although no previous study has reported the interaction between long working hours and other psychosocial stressors based on an additive scale, several studies have suggested there could be an interaction between long working hours and psychosocial working conditions. A study among British civil servants reported that the odds ratio between long working hours and major depressive disorders increased when SES and job stressors were adjusted(109). That study did not directly investigate the subpopulation among British civil servants that worked long hours. However, another study of the same population found that higher-level civil servants—usually associated with high job control—tended to work long hours(109). The results suggested that a higher grade and high job control might reduce the detrimental effects of long working hours on mental health.

Another study reported that the incidence of type II diabetes mellitus

increased among individuals with low SES, although long working hours were not associated with such an increase among all participants.(117) These results suggest that high job control and higher social position might ameliorate the harmful influence of long working hours. Conversely, long working hours might be more harmful under unfavorable psychosocial working conditions due to higher exposure to adverse conditions. By contrast, in Korea, a significant proportion of employees with low SES worked long hours, as shown in Table 1. This phenomenon could imply that workers with low SES have to work long hours to meet basic needs and to compensate for low hourly wages. Similarly, in another Korean study, simultaneous exposure to both long working hours and precarious employment had a greater effect on depression than exposure to just one or the other (although that study did not include an interaction analysis based on the additive scale).(118) These results might reflect the heavy burdens (simultaneous exposure to long working hours and low job control) borne by Korean employees with low SES.

To explore the interaction between SES and long working hours, an additional interaction analysis—which included gender, age, employment status, income, smoking, alcohol consumption, and shift work as covariates—was conducted for the same population. We did not find a

significant interaction between educational level and long working hours on the additive scale (RERI: 0.15; 95% CI: 0.08–0.32; *p*=0.062). Moreover, it is unclear whether there an interaction exists between long working hours and low job control in other populations. To enhance external validity, an additional analysis using a similar survey among different populations (e.g., European workers) should be conducted in the future.

Suggestion for Strict Regulation of More than 52 Working Hours a Week

With the introduction of the five-day work week in 2002, the Labor Standards Act limited weekly working hours to 52 hours with the employee's consent. The legal limit for working hours has been a controversial issue in Korea.(119) The Korean government, especially the Department of Employment and Labor, has not regarded working more than 52 hours as illegal since working an additional 16 hours on the weekend is excluded from the calculation. Based on this interpretation of the Labor Standards Act, employers have been able to encourage employees to work additional hours on the weekend without violating the law. However, the courts have changed their opinion regarding limits on weekly working hours. There is some judicial

precedent that additional weekend hours should be included in weekly working hours.(119-121) Accordingly, the debate concerning limits on weekly working hours requires a sociopolitical solution.(23, 112, 122) The findings of the present study suggest that more strict regulations on working hours should be implemented. In particular, strict regulation on working hours to not exceed 52 hours per week could significantly improve the health of vulnerable subpopulations (e.g., employees with low job control, which is generally related to low SES).

Study Limitations

Although this study used a large, nationally representative sample, it has several limitations. First, the cross-sectional nature of the study could not establish a causal relationship between exposure and health outcomes. Since employees tend to reduce working hours when they are sick, poor self-rated health might not lead to long working hours. Thus, the possibility of reverse causation between poor self-rated health and long working hours might be low. It is also possible that poor self-rated health could contribute to the perception of low job control. Given the nature of cross-sectional study, we cannot exclude the possibility of reverse causation. However, the results of the present study are consistent with the results of other cohort studies that reported low job control and

adverse health outcomes.(23, 112, 123)

Second, the measurement of working hours and health status was subjective and could be subject to information bias. In particular, self-rated health is a subjective measurement of health status. However, previous research, including a prospective cohort study, has consistently reported that poor self-rated health is linked with objective health outcomes, such as mortality.(124-126) Even after adjusting for other health-related covariates, self-rated health could predict future mortality.

Third, the validity and reliability of the questionnaires used for the 3rd KWCS were not estimated, although a previous study reported that the 2nd KWCS survey was valid and reliable.

Finally, we assessed job control using a single question related to decision authority. Thus, this single question might not capture other aspects of job control, especially skill discretion, which is another component of low job control. Although the reliability of this single question might be debatable, the authors believe this question arguably measures one of the most important aspects of job control.

Conclusion

This study's findings suggest a need to adjust policies regarding working hours. Long working hours under stressful working conditions might

have a synergistic negative effect on health. In particular, the health of a vulnerable subpopulation (workers with low job control) might be significantly improved by reducing the number of working hours. In addition, the health of the average population might be improved by reducing the working hours of those who work more than 52 hours (the legal limit) in Korea. Along with strict regulations on working hours, the minimum wage should be increased to support healthy living conditions for those who work the standard number of hours.(127) Moreover, social protection programs for the unemployed should be improved.

Discussion of thesis

Are gradients in occupational hazard exposures ethical?

The fact that people with lower socioeconomic status (SES) are more frequently exposed to occupational hazards to maintain today's production systems is accepted as an obvious reality. Some can make voluntary choices for their own occupation, but more often than not, occupational choices go through the process of social stratification. The reality is that when individuals obtains jobs, that decision is linked with educational attainment, skill levels, and social capitals, such as interpersonal relationships.(128) As a result of social stratification, people with lower SES tend to work in more hazardous environments. However, the fact that people with lower SES have to work in more hazardous environments could pose an ethical issue.(129) Furthermore, the fact that people with lower SES without enough information on workplace safety and health and without proper protective measures for their health and safety are working in these environments further deviates from the principle of social justice.

Furthermore, exposure to occupational hazards, reduced workplace safety, and health inequality can be reduced by improving the working condition workers with lower SES and putting forth social efforts, such as

a proper labor inspection of working conditions including safety (avoidability). Therefore, health inequality due to occupational hazards would match the definition of health inequity, and reducing health inequality from this would also fit the principle of equity.(1, 2) To reduce health inequality that is generated in the workplace, more thorough preventive measurements are required for harmful occupational exposures which are more prevailed in manual workers and workers under unstable employment. The preventive measurements for health problems caused by occupational hazard exposures could be a high priority policy for reducing health inequality.

Hazardous working conditions combined with unstable employment

The thesis showed that unstable employment and perceived risk of workplace safety or health had a negative impact on self-rated health status, and it was found that risks associated with unstable employment and perceived workplace safety and health had both additive and multiplicative interactions. Meanwhile, an analysis of European Union (EU) workers showed that only the perceived risk of workplace safety or health had an impact on self-rated health, but not unstable employment. Among European workers, interactions between unstable employment

status and perceived risk of safety or health were not observed at neither additive nor multiplicative scales.

It is suspected that such results are associated with social inequality faced by Korean precarious workers. Unstable employment is not simply an issue of short contract periods, and such interactions may have appeared because workers with unstable employment can be working in more dangerous or harmful circumstances. In addition, the income disparity between stable and unstable employment may be linked with these observed interactions. Reducing the income gap between regular and non-regular workers and simultaneously improving the working conditions of precarious workers can be one pathway for reducing health inequality.

Industrial accidents are much more prevalent among workers under unstable employment, such as dispatched, subcontract, and daily workers. However, there are insufficient systematic investigations on working conditions which precarious workers have to bear.

Although there are some preventive measurements for workplace safety and control exposure to occupational hazards, such managements for improving working conditions is generally confined to regular workers in medium-to-large companies with 50 or more employees in Korea. Implementations of improving workplace safety and controlling

occupational hazard exposures are not properly carried out for workers who work in small-sized workplaces with less than 50 employees, workers in subcontractors, and other precarious workers.(88, 90)

To reduce the health gap between workers under stable employment and workers under unstable employment, several policies might be needed. Most of all, more thorough investigations on workplace safety and working conditions, as well as continuous monitoring of the exposure gaps of dangerous or harmful working conditions between regular workers and non-regular workers are required. Moreover, working conditions of non-regular workers should be improved in accordance with the exposure gaps measured in investigations and monitoring.

Long working hours and health inequality

Working hours in Korea has been longer than other OECD countries, and a high percentage of workers has exceeded the legal limit of 52 hours per week.(98, 122) There are several social reasons for long work hours in Korea. Since white-collar workers work under a blank wage system, their work hours can be extended without paying extra wages. On the other hand, blue-collar workers are paid an hourly wage, but their wages can increase significantly from overtime working when they

extend working hours, which are closely associated with long working hours. Moreover, workers who are paid low hourly wages, close to the minimum wage, are often forced to extend working hours to maintain their livelihood.(99)

Long working hours under low job control was found to have a larger magnitude than an additive interaction, which indicated that long working hours under low job control might be more harmful. Reducing long work hours could improve the self-rated health of employees with low job control, which are generally associated with low SES. Considering the results of this thesis, it may also could be a path for reducing the gradient in health. In addition to reducing health problems of workers who have to extend their working hours to compensate for low wages per hour, the minimum wage should be raised to the level that can maintain healthy lives for workers when they work the standard working hours.(127)

Health inequality and statistics on occupational injuries and work-related diseases in Korea

Statistics on industrial accidents and diseases in Korea are based on the number of injuries and disease recognized by workers' compensation. However, occupational injuries and diseases have a tendency of being

under-reported. It is also known that under-reported occupational injuries and work-related diseases are more common among precarious workers or workers in small-sized workplaces due to the lower claim rate.(130) Current enrollment of workers' compensation is based on the enterprise. The size (the number of employees) and type of industry are recorded for the payment of insurance premiums. However, the characteristics of individual workers, including SES, have not yet been investigated. Only when an occupational injury or disease occurs, whether the workplace of the injured workers are the primary contractors or subcontractors and whether the workers are regular, temporary, or daily workers, are investigated. However, the SES of the workers who experience the injury or disease in such occupations is currently not surveyed. Official published statistics on industrial accidents only report the occurrence of accidents according to industry type and size of workplace, while occurrences of industrial accidents based on the principle of equity are not assessed. Therefore, statistics on occupational injuries and work-related diseases should be improved and monitoring of occupational injury and disease should be based on the principle of health equity. In addition, more social efforts are needed to reduce under-reporting of occupational injuries and work-related diseases, which are expected to be concentrated among workers with lower SES.

The need for monitoring health inequality owing to the gradient in occupational hazard exposures

As explored in this thesis, occupations and employment status were associated with various occupational hazard exposures, as well as health inequality. Yet, the monitoring of health inequality generated in the workplace has not been implemented. Social efforts for reducing health inequality linked occupational hazard exposures have been insufficient.

In this thesis, health inequality and the gradient in occupational hazard exposures in the workplace were observed. However, such results are based on subjective assessment using the questionnaire. For more objective exposure assessment for working conditions, thorough investigations on working conditions should be carried out by professional industrial hygienists and safety professionals. At first as a trial, objective working conditions of some proportion in the sample from KWCS could be investigated by professional industrial hygienists and safety professionals.

Subsequently, health inequality due to the gradient in occupational hazard exposures should be continuously monitored. Policies should be established based on the monitoring the health inequality, which is generated in the workplace.

Limitations of study

Since this is a cross-sectional study, temporality could not be accounted for, which made it difficult to assess the causal relationship. Particularly, the association between poor self-rated health and perceived risk of safety and health in the workplace or occupational hazard exposure may have been due to reverse causation. It is possible that people with poor health may have assessed that their workplace was dangerous or harmful or responded that they were exposed to occupational hazards. The nature of a cross-sectional study may also render the effects of occupational hazard exposures weaker, due to the “healthy worker effect” or “healthy worker survivor effect”.

Each chapter was analyzed under slightly different assumptions. In Chapter 2, mediation analysis was conducted under the assumption that each exposure was independent. In Chapter 3, interaction analysis was performed on the interaction between employment status and perceived workplace risks. In Chapter 4, interaction between working long hours and low job control was analyzed. The reason why different assumptions were used in each chapter was because the objective of each chapter was different from that of the others. The goal of Chapter 2 was to examine that general workplace safety and occupational hazard

exposures could be an important path, as like income inequality and unstable employment. Meanwhile, the aims of Chapters 3 and 4 were to examine whether the harmful effects increased due to interactions between occupational hazard exposures when concurrently exposed.

Conclusion

This thesis showed that workplace safety and working conditions could be important factors influencing health inequality, especially in the economically active age population of Korea. There were gradients in occupational hazard exposures across occupations and employment statuses, and associations between exposure to various occupational hazards and poor self-rated health were observed. Moreover, through the mediation analysis that perceived risk of workplace safety and health, long work hours and unstable employment can result in health inequality. Furthermore, through the interaction analysis, when workers are under unstable employment and perceived risks of workplace safety and health simultaneously, it can have a more harmful effect on self-rated health due to the interaction. Long working hours under low job control can also have a more detrimental effect on health due to the interaction. To reduce health inequality among economically active age population of Korea, it is necessary to reduce economic inequalities such as the

income gap, and improve, the harmful and dangerous work conditions, which are concentrated among employees with low socioeconomic status by the principle of proportionate universalism. Considering the results of the interaction analysis, safety and working conditions of precarious workers should be improved more urgently. Reducing long working hours, which are more prevalent in employees with lower SES, could also be an important way for reducing health inequality.

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Appendix tables: Occupational hazard exposures by occupations and employment status in EU 15 countries and EU countries with survey weighted analysis

Table A.1. Physical hazard exposures by occupations and employment status among employees in EU15 countries

	Total		Permanent		Fixed term or temporary	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Vibration						
Professional & manage	4230(0.93)	297(0.07)	3595(0.93)	256(0.07)	559(0.93)	37(0.07)
Clerical & technician	4759(0.89)	565(0.11)	4007(0.89)	494(0.11)	634(0.91)	64(0.09)
Service & sales	2779(0.91)	285(0.09)	1967(0.90)	225(0.10)	724(0.94)	50(0.06)
Manual	2779(0.51)	2721(0.49)	2110(0.50)	2097(0.50)	603(0.53)	539(0.47)
Noise						
Professional & manage	3523(0.78)	1004(0.22)	3023(0.78)	829(0.22)	447(0.75)	147(0.25)
Clerical & technician	4449(0.84)	878(0.16)	3753(0.83)	751(0.17)	591(0.85)	108(0.15)
Service & sales	2362(0.77)	704(0.23)	1676(0.77)	516(0.23)	169(0.80)	157(0.20)
Manual	2660(0.48)	2841(0.52)	1991(0.47)	2218(0.53)	602(0.53)	540(0.47)
High temperature						
Professional & manage	3948(0.87)	582(0.13)	3350(0.87)	502(0.13)	523(0.87)	73(0.13)
Clerical & technician	4503(0.85)	825(0.15)	3807(0.84)	700(0.16)	588(0.84)	108(0.16)
Service & sales	2424(0.79)	642(0.21)	1706(0.78)	487(0.22)	637(0.82)	139(0.18)
Manual	3454(0.63)	2031(0.37)	2636(0.63)	1565(0.37)	728(0.64)	410(0.36)

Low temperature						
Professional & manage	3987(0.88)	533(0.12)	3402(0.88)	445(0.12)	518(0.88)	74(0.12)
Clerical & technician	4596(0.86)	728(0.14)	3876(0.86)	625(0.14)	613(0.88)	86(0.12)
Service & sales	2496(0.81)	568(0.19)	1766(0.81)	423(0.19)	648(0.84)	128(0.16)
Manual	3407(0.62)	2085(0.38)	2637(0.63)	1569(0.37)	690(0.61)	448(0.39)

Table A.2. Chemical hazard exposures by occupations and employment status among employees in EU15 countries

	Total		Permanent		Fixed term or temporary	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Dust, fume, smoke						
Professional & manage	4277(0.95)	245(0.05)	3639(0.95)	209(0.05)	563(0.95)	30(0.05)
Clerical & technician	4947(0.93)	377(0.07)	4177(0.93)	327(0.07)	651(0.94)	45(0.06)
Service & sales	2833(0.92)	231(0.08)	2010(0.92)	179(0.08)	729(0.94)	47(0.06)
Manual	3501(0.64)	1991(0.36)	2604(0.62)	1596(0.38)	800(0.70)	343(0.30)
Solvents						
Professional & manage	4325(0.96)	187(0.04)	3684(0.96)	158(0.04)	563(0.95)	28(0.05)
Clerical & technician	5048(0.95)	274(0.05)	4277(0.95)	223(0.05)	657(0.94)	41(0.06)
Service & sales	2873(0.94)	189(0.06)	2047(0.94)	142(0.06)	735(0.95)	39(0.05)
Manual	4399(0.80)	1088(0.20)	3364(0.80)	832(0.20)	916(0.80)	226(0.20)
Contact with chemicals						
Professional & manage	4137(0.92)	382(0.08)	3530(0.92)	314(0.08)	535(0.90)	59(0.10)
Clerical & technician	4846(0.91)	473(0.09)	4086(0.91)	414(0.09)	648(0.93)	49(0.07)
Service & sales	2692(0.88)	366(0.12)	1912(0.87)	275(0.13)	698(0.90)	77(0.10)
Manual	4058(0.74)	1440(0.26)	3122(0.74)	1084(0.26)	831(0.73)	312(0.27)
Environmental smoking						
Professional & manage	4317(0.96)	200(0.04)	3693(0.96)	152(0.04)	555(0.93)	40(0.07)

Clerical & technician	4926(0.93)	392(0.07)	4169(0.93)	329(0.07)	642(0.92)	55(0.08)
Service & sales	2720(0.89)	343(0.11)	1949(0.89)	244(0.11)	681(0.88)	92(0.12)
Manual	4601(0.84)	886(0.16)	3529(0.84)	670(0.16)	950(0.83)	190(0.17)
Infectious agents						
Professional & manage	3968(0.88)	555(0.12)	3381(0.87)	466(0.13)	519(0.87)	76(0.13)
Clerical & technician	4731(0.89)	590(0.11)	4001(0.89)	498(0.11)	623(0.89)	75(0.11)
Service & sales	2581(0.84)	483(0.16)	1817(0.83)	374(0.17)	673(0.87)	101(0.13)
Manual	4785(0.87)	697(0.13)	3655(0.87)	538(0.13)	999(0.88)	139(0.12)

Table A.3. Psychosocial hazard exposures by occupation and employment status among employees in EU15 countries

	Total		Permanent		Fixed term or temporary	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Low job decision						
Professional & manage	3742(0.83)	763(0.17)	3209(0.84)	623(0.16)	469(0.79)	123(0.21)
Clerical & technician	3514(0.66)	1778(0.44)	3058(0.68)	1418(0.32)	390(0.56)	303(0.44)
Service & sales	1742(0.58)	1287(0.42)	1352(0.62)	814(0.38)	340(0.44)	425(0.56)
Manual	2696(0.49)	2753(0.51)	2216(0.53)	1958(0.47)	420(0.37)	707(0.63)
Perceived stress						
Professional & manage	3206(0.71)	1322(0.29)	2716(0.71)	1135(0.29)	427(0.72)	168(0.28)
Clerical & technician	3880(0.73)	1444(0.27)	3252(0.72)	1250(0.28)	536(0.77)	162(0.23)
Service & sales	2264(0.74)	800(0.26)	3251(0.73)	1250(0.27)	595(0.77)	180(0.23)
Manual	4213(0.77)	1273(0.23)	3215(0.77)	983(0.23)	874(0.77)	263(0.23)
Hide own emotion						
Professional & manage	2173(0.75)	733(0.25)	1819(0.74)	623(0.26)	314(0.77)	96(0.23)
Clerical & technician	3465(0.87)	517(0.13)	2868(0.86)	450(0.14)	508(0.90)	53(0.10)
Service & sales	2209(0.88)	313(0.12)	1528(0.86)	242(0.14)	609(0.90)	65(0.10)
Manual	4169(0.93)	330(0.07)	3091(0.92)	271(0.08)	953(0.95)	51(0.05)
Shift work						
Professional & manage	4034(0.90)	463(0.10)	3424(0.90)	399(0.10)	543(0.91)	51(0.09)

Clerical & technician	4586(0.87)	712(0.13)	3879(0.87)	606(0.13)	601(0.87)	90(0.13)
Service & sales	2214(0.73)	815(0.27)	1552(0.72)	613(0.28)	581(0.76)	184(0.24)
Manual	4399(0.80)	1075(0.20)	3313(0.79)	880(0.21)	956(0.84)	177(0.16)
Perceived health or safety risk						
Professional & manage	3680(0.82)	809(0.18)	3134(0.82)	685(0.18)	477(0.81)	112(0.19)
Clerical & technician	4424(0.84)	852(0.16)	3720(0.84)	734(0.16)	594(0.86)	97(0.14)
Service & sales	2383(0.79)	638(0.21)	1664(0.77)	506(0.23)	631(0.84)	123(0.16)
Manual	3490(0.65)	1871(0.35)	2656(0.65)	1444(0.35)	742(0.67)	372(0.33)

Table A.4. Ergonomic hazard exposures by occupations and employment status among employees in EU15 countries

	Total		Permanent		Fixed term or temporary	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Tiring or painful posture						
Professional & manage	3634(0.81)	878(0.19)	3098(0.81)	739(0.19)	468(0.79)	128(0.21)
Clerical & technician	4149(0.78)	1168(0.22)	3516(0.78)	980(0.22)	536(0.77)	161(0.23)
Service & sales	2016(0.66)	1042(0.34)	1437(0.66)	756(0.44)	513(0.67)	257(0.33)
Manual	2767(0.50)	2718(0.50)	2184(0.52)	2013(0.48)	517(0.45)	622(0.55)
Lifting or moving people						
Professional & manage	4153(0.92)	370(0.08)	3540(0.92)	307(0.08)	541(0.90)	55(0.10)
Clerical & technician	5045(0.95)	280(0.05)	4270(0.95)	233(0.05)	657(0.94)	40(0.06)
Service & sales	2632(0.86)	431(0.14)	1877(0.86)	315(0.14)	670(0.86)	103(0.14)
Manual	5310(0.97)	186(0.03)	4061(0.97)	145(0.03)	1104(0.97)	37(0.03)
Heavy loads						
Professional & manage	4238(0.94)	287(0.06)	3601(0.94)	249(0.06)	559(0.94)	36(0.06)
Clerical & technician	4842(0.91)	485(0.09)	4092(0.91)	413(0.09)	634(0.90)	65(0.10)
Service & sales	2468(0.81)	596(0.19)	1744(0.80)	448(0.20)	643(0.83)	130(0.17)
Manual	3488(0.63)	2014(0.37)	2698(0.64)	1512(0.36)	705(0.62)	438(0.48)
Standing						
Professional & manage	2374(0.53)	2148(0.47)	2048(0.53)	1798(0.47)	285(0.48)	311(0.52)

Clerical & technician	3636(0.68)	1687(0.32)	3091(0.69)	1410(0.31)	463(0.66)	235(0.44)
Service & sales	590(0.19)	2475(0.81)	436(0.20)	1757(0.80)	144(0.19)	630(0.81)
Manual	1235(0.22)	4259(0.78)	1027(0.24)	3176(0.76)	198(0.17)	944(0.83)
Repetitive movement						
Professional & manage	2710(0.60)	1812(0.40)	2300(0.60)	1548(0.40)	357(0.60)	237(0.40)
Clerical & technician	2693(0.51)	2630(0.49)	2294(0.51)	2209(0.49)	323(0.46)	374(0.54)
Service & sales	1334(0.44)	1729(0.56)	977(0.45)	1215(0.55)	317(0.41)	455(0.59)
Manual	1650(0.27)	2997(0.73)	1185(0.28)	3020(0.72)	277(0.24)	865(0.76)

Table A.5. Personal protective equipment and information on safety and health by occupations and employment status among employees in EU15 countries

	Total		Permanent		Fixed term or temporary	
	No	Yes	No	Yes	No	Yes
	N(proportion)	N(proportion)	N(proportion)	N(proportion)	N(proportion)	N(proportion)
are PPEs required?						
Professional & manage	3282(0.73)	1238(0.27)	2772(0.72)	1073(0.28)	445(0.75)	149(0.25)
Clerical & technician	3930(0.74)	1890(0.27)	3301(0.73)	1200(0.27)	544(0.78)	154(0.22)
Service & sales	2056(0.67)	1009(0.33)	1419(0.65)	773(0.35)	570(0.74)	204(0.26)
Manual	1795(0.33)	3691(0.67)	1345(0.32)	2852(0.68)	407(0.36)	735(0.64)
Not PPE use, if required						
Professional & manage	1132(0.92)	103(0.08)	990(0.92)	81(0.08)	128(0.86)	20(0.13)
Clerical & technician	1278(0.92)	109(0.08)	1101(0.92)	96(0.08)	142(0.92)	12(0.08)
Service & sales	940(0.93)	67(0.07)	719(0.93)	54(0.07)	193(0.95)	11(0.05)
Manual	3308(0.90)	370(0.10)	2581(0.91)	259(0.09)	646(0.88)	88(0.12)
Poorly provided Information on Safety and Health						
Professional & manage	4017(0.90)	436(0.10)	3442(0.91)	355(0.09)	503(0.87)	74(0.13)
Clerical & technician	4692(0.90)	535(0.10)	4008(0.90)	421(0.10)	573(0.84)	105(0.16)
Service & sales	2587(0.86)	416(0.14)	1892(0.88)	267(0.12)	613(0.82)	135(0.18)
Manual	4634(0.85)	804(0.15)	3629(0.87)	548(0.13)	886(0.79)	542(0.21)

Table A.6. Physical hazard exposures by occupations and employment status among employees in EU countries

	Total		Permanent		Fixed term or temporary	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Vibration						
Professional & manage	7433(0.93)	563(0.07)	6161(0.93)	455(0.07)	1142(0.92)	102(0.08)
Clerical & technician	8182(0.89)	1036(0.11)	6724(0.89)	838(0.11)	1303(0.88)	182(0.12)
Service & sales	5327(0.89)	635(0.11)	3603(0.89)	457(0.11)	1586(0.91)	165(0.09)
Manual	5588(0.49)	5920(0.51)	4002(0.48)	4355(0.52)	1488(0.51)	1425(0.49)
Noise						
Professional & manage	6128(0.77)	1878(0.23)	5098(0.77)	1524(0.23)	934(0.75)	313(0.25)
Clerical & technician	7621(0.83)	1599(0.17)	6270(0.83)	1293(0.17)	1208(0.81)	278(0.19)
Service & sales	5327(0.77)	1395(0.23)	3106(0.76)	956(0.23)	1356(0.77)	396(0.23)
Manual	5326(0.46)	6185(0.54)	3781(0.45)	4578(0.55)	1436(0.49)	1479(0.51)
High temperature						
Professional & manage	6850(0.88)	893(0.12)	5840(0.88)	783(0.12)	1087(0.87)	158(0.13)
Clerical & technician	7562(0.85)	1369(0.15)	6447(0.85)	1122(0.15)	1238(0.83)	247(0.17)
Service & sales	5553(0.78)	1550(0.22)	3146(0.78)	907(0.22)	1361(0.78)	390(0.22)
Manual	6589(0.60)	4334(0.40)	5070(0.61)	3254(0.39)	1619(0.55)	1295(0.45)

Low temperature						
Professional & manage	7023(0.88)	969(0.12)	5837(0.88)	780(0.12)	1067(0.86)	172(0.14)
Clerical & technician	7831(0.85)	1382(0.15)	6439(0.85)	1119(0.15)	1250(0.84)	233(0.16)
Service & sales	4709(0.79)	1244(0.21)	3195(0.79)	858(0.21)	1392(0.79)	359(0.21)
Manual	6701(0.58)	4772(0.42)	5002(0.60)	3336(0.40)	1574(0.54)	1325(0.46)
Perceived health or safety risk at work						
Professional & manage	6468(0.81)	1470(0.19)	5342(0.81)	1223(0.19)	1011(0.82)	228(0.18)
Clerical & technician	7331(0.81)	1769(0.19)	5997(0.80)	1475(0.20)	1202(0.82)	259(0.18)
Service & sales	4507(0.77)	1357(0.23)	2963(0.74)	1040(0.26)	1418(0.83)	297(0.17)
Manual	6599(0.59)	4506(0.41)	4755(0.59)	3372(0.41)	1705(0.60)	1143(0.40)

Table A.7. Chemical hazard exposures by occupations and employment status among employees in EU countries

	Total		Permanent		Fixed term or temporary	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Dust, fume, smoke						
Professional & manage	7552(0.95)	449(0.05)	6250(0.94)	370(0.06)	1173(0.94)	70(0.06)
Clerical & technician	8453(0.92)	766(0.08)	6936(0.92)	630(0.08)	1363(0.92)	120(0.08)
Service & sales	5410(0.91)	549(0.08)	3666(0.90)	391(0.10)	1602(0.91)	150(0.09)
Manual	7107(0.62)	4385(0.38)	5087(0.61)	3261(0.39)	1870(0.64)	1038(0.36)
Solvents						
Professional & manage	7661(0.96)	328(0.04)	6341(0.96)	272(0.04)	1190(0.96)	51(0.04)
Clerical & technician	8677(0.94)	534(0.06)	7134(0.94)	423(0.06)	1386(0.93)	98(0.07)
Service & sales	5564(0.94)	384(0.06)	3769(0.93)	280(0.07)	1657(0.95)	93(0.05)
Manual	9040(0.79)	2435(0.21)	6558(0.79)	1774(0.21)	2301(0.79)	606(0.21)
Contact with chemicals						
Professional & manage	7373(0.92)	619(0.08)	6118(0.93)	492(0.07)	1131(0.91)	115(0.09)
Clerical & technician	833(0.91)	869(0.09)	6840(0.91)	710(0.09)	1346(0.91)	137(0.09)
Service & sales	5266(0.89)	685(0.11)	3558(0.88)	495(0.12)	1577(0.90)	171(0.10)
Manual	8615(0.75)	2877(0.25)	626$(0.75)	2083(0.25)	2192(0.75)	720(0.25)
Environmental smoking						
Professional & manage	7481(0.94)	820(0.06)	6236(0.94)	373(0.06)	1121(0.90)	120(0.10)

Clerical & technician	8359(0.91)	842(0.09)	6892(0.91)	658(0.09)	13116(0.89)	164(0.11)
Service & sales	5102(0.86)	852(0.14)	3522(0.87)	534(0.13)	1449(0.83)	299(0.17)
Manual	9134(0.80)	2346(0.20)	6725(0.81)	1619(0.19)	2226(0.77)	677(0.23)
Infectious agents						
Professional & manage	7172(0.90)	820(0.10)	5958(0.90)	655(0.10)	1098(0.88)	145(0.12)
Clerical & technician	8209(0.89)	994(0.11)	6735(0.89)	8115(0.11)	1331(0.90)	151(0.10)
Service & sales	5190(0.87)	759(0.13)	3484(0.86)	566(0.14)	1567(0.90)	181(0.10)
Manual	9901(0.86)	1559(0.14)	7197(0.86)	1131(0.14)	2502(0.86)	398(0.14)

Table A.8. Psychosocial hazard exposures by occupations and employment status among employees in EU countries

	Total		Permanent		Fixed term or temporary	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Low job decision						
Professional & manage	6638(0.84)	1324(0.16)	5556(0.84)	1028(0.16)	978(0.79)	262(0.21)
Clerical & technician	6061(0.66)	3079(0.34)	5098(0.68)	2403(0.32)	864(0.59)	609(0.41)
Service & sales	3403(0.58)	2456(0.42)	24501(0.61)	1544(0.39)	876(0.50)	845(0.50)
Manual	5480(0.49)	5844(0.52)	4162(0.50)	4096(0.50)	1225(0.43)	1613(0.57)
Perceived stress						
Professional & manage	5715(0.71)	2281(0.29)	4712(0.71)	1902(0.29)	900(0.72)	345(0.28)
Clerical & technician	6709(0.73)	2501(0.27)	5510(0.72)	2047(0.28)	1074(0.72)	410(0.28)
Service & sales	4430(0.75)	1492(0.25)	34014(0.75)	1027(0.25)	1303(0.75)	430(0.25)
Manual	8810(0.77)	2643(0.23)	6445(0.77)	1878(0.23)	2177(0.75)	717(0.25)
Hide own emotion						
Professional & manage	3798(0.73)	1393(0.27)	3092(0.73)	1156(0.27)	633(0.75)	210(0.25)
Clerical & technician	5947(0.85)	1073(0.15)	4795(0.84)	897(0.16)	1039(0.87)	156(0.13)
Service & sales	4235(0.86)	683(0.14)	2839(0.86)	470(0.14)	1292(0.87)	198(0.13)
Manual	8684(0.92)	761(0.08)	6225(0.92)	540(0.08)	2270(0.92)	209(0.08)
Shift work						
Professional & manage	7123(0.90)	835(0.10)	5882(0.89)	694(0.11)	1120(0.90)	127(0.10)

Clerical & technician	7717(0.84)	1452(0.16)	6351(0.84)	1177(0.16)	1221(0.83)	252(0.17)
Service & sales	3774(0.64)	2138(0.36)	2459(0.61)	1565(0.39)	1204(0.69)	536(0.31)
Manual	8925(0.78)	2536(0.22)	6332(0.76)	2000(0.24)	2386(0.82)	509(0.18)

Table A.9. Ergonomic hazard exposures by occupations and employment status among employees in EU countries

	Total		Permanent		Fixed term or temporary	
	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)	Exposure(-) N(proportion)	Exposure(+) N(proportion)
Tiring or painful posture						
Professional & manage	6443(0.81)	1550(0.19)	5374(0.81)	1233(0.19)	957(0.77)	293(0.23)
Clerical & technician	7100(0.77)	2102(0.23)	5880(0.77)	1668(0.23)	1090(0.73)	393(0.27)
Service & sales	3939(0.66)	2007(0.34)	2683(0.66)	1366(0.34)	1161(0.66)	587(0.34)
Manual	5496(0.48)	5992(0.52)	4195(0.50)	4145(0.50)	1197(0.41)	1716(0.59)
Lifting or moving people						
Professional & manage	7490(0.94)	513(0.06)	6201(0.94)	415(0.06)	1165(0.93)	85(0.07)
Clerical & technician	8741(0.95)	472(0.05)	7169(0.95)	387(0.05)	1414(0.95)	72(0.05)
Service & sales	5325(0.89)	635(0.11)	3609(0.89)	449(0.11)	1583(0.90)	169(0.10)
Manual	11125(0.97)	370(0.03)	8093(0.97)	259(0.03)	2803(0.96)	104(0.04)
Heavy loads						
Professional & manage	7591(0.94)	417(0.06)	6279(0.95)	341(0.05)	1178(0.94)	72(0.06)
Clerical & technician	8337(0.90)	878(0.10)	6869(0.91)	689(0.09)	1315(0.89)	169(0.11)
Service & sales	4773(0.80)	1185(0.20)	3217(0.79)	839(0.21)	1440(0.82)	310(0.18)
Manual	7197(0.63)	4309(0.37)	5385(0.64)	2971(0.36)	1682(0.58)	1230(0.42)
Standing						
Professional & manage	4306(0.54)	3702(0.46)	3667(0.55)	2955(0.45)	582(0.47)	669(0.53)

Clerical & technician	6247(0.68)	2964(0.32)	5199(0.69)	2357(0.31)	943(0.63)	542(0.37)
Service & sales	1200(0.20)	4760(0.80)	850(0.21)	3208(0.79)	328(0.19)	1424(0.81)
Manual	3068(0.27)	8435(0.73)	2398(0.29)	5957(0.71)	642(0.22)	2271(0.78)
Repetitive movement						
Professional & manage	4880(0.61)	3117(0.38)	4074(0.62)	2538(0.38)	723(0.58)	525(0.42)
Clerical & technician	4812(0.52)	4379(0.48)	4004(0.53)	3540(0.47)	711(0.48)	768(0.52)
Service & sales	2715(0.46)	3230(0.54)	1862(0.46)	2185(0.54)	793(0.45)	956(0.55)
Manual	3092(0.27)	8398(0.73)	2380(0.29)	5967(0.71)	659(0.23)	2247(0.77)

Table A.10. Personal protective Equipment and information on safety and health by occupations and employment status among employees in EU15 countries

	Total		Permanent		Fixed term or temporary	
	No	Yes	No	Yes	No	Yes
	N(proportion)	N(proportion)	N(proportion)	N(proportion)	N(proportion)	N(proportion)
are PPEs required?						
Professional & manage	5979(0.75)	2027(0.25)	4915(0.74)	1709(0.26)	956(0.77)	289(0.23)
Clerical & technician	6699(0.73)	2518(0.27)	5461(0.72)	2102(0.28)	1123(0.76)	364(0.24)
Service & sales	3938(0.66)	2021(0.34)	2554(0.63)	1511(0.37)	1289(0.74)	457(0.26)
Manual	3901(0.34)	7601(0.66)	2668(0.32)	5688(0.68)	1165(0.40)	1748(0.60)
Not PPE use, if required						
Professional & manage	1843(0.91)	173(0.09)	1557(0.91)	145(0.09)	262(0.92)	24(0.08)
Clerical & technician	2183(0.92)	195(0.08)	1937(0.92)	161(0.08)	334(0.92)	29(0.08)
Service & sales	22271(0.94)	142(0.06)	1414(0.94)	91(0.06)	428(0.94)	27(0.06)
Manual	6451(0.91)	650(0.09)	5172(0.91)	490(0.09)	1541(0.89)	199(0.11)
Poorly provided Information on Safety and Health						
Professional & manage	7090(0.92)	613(0.08)	6071(0.93)	477(0.07)	1095(0.90)	126(0.10)
Clerical & technician	8251(0.90)	815(0.10)	6838(0.92)	613(0.08)	1258(0.87)	191(0.13)
Service & sales	5122(0.88)	728(0.12)	3582(0.89)	424(0.11)	1411(0.83)	286(0.17)
Manual	9814(0.86)	1588(0.14)	7369(0.89)	941(0.11)	2250(0.79)	610(0.21)

국문 초록

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환경보건전공

조 성 식

태내 환경에서 시작하여 출생, 성장과 교육, 성인기의 노동시장에 참여하여 일을 하는 것 그리고 은퇴 이후의 삶의 과정에서 생활 여건은 건강에 매우 중요한 영향을 미친다. 불평등한 사회 구조와 관계는 낮은 사회경제적 지위의 사람들이 건강에 해로울 수 잠재적 위험 요인에 더 많이 노출될 수 있는 환경을 만들어 왔다. 불평등한 사회 구조와 관계에서 낮은 사회경제적 지위의 사람들이 잠재적인 건강의 위험요인에 더 많이 노출되는 것은 건강불평등의 주요 경로로 알려져 있다.

성인기 삶에서 노동조건과 고용조건은 건강과 밀접한 관련을 가진다. 노동시장에 참여해서 일을 하는 것은 건강에 긍정적인 영향을 주기도 하고 일을 하는 과정과정에 건강에 해로운 위험 요인에 노출되기도 한다. 대부분의 사람들에게 일은 생활을 영위할 수 있는 소득의 주요 원천이기도 하고, 직업은 사회적 지위와 깊이 관련되어 있으며, 자아 정체감을 형성할 수도 있으며 일터는 성인기의 사회적 관계 맺기의 중요한 장이기도 하다. 또 한편 일을 하는 것은 건강에 해로울 수 있는 여러 위해요인 노출을 의미하기도 한다. 일을 하게 됨으로써 물리적, 화학적, 인간공학적 그리고 사회심리적 위험 요인에 노출될

수 있으며, 낮은 사회경적 지위의 사람들이 더 해로운 작업 환경에서 일하게 되는 것은 성인기 건강 불평등의 중요한 경로가 될 수 있다. 1992년 영국의 공무원에서 지위에 따른 건강격차를 연구한 2차 화이트홀 연구 이후 일과 관련한 건강 불평등 연구는 직무 스트레스와 같은 사회심리적 요인에 초점을 맞추어 왔다. 사회심리적 요인에 대한 관심의 증대는 탈산업화 이후 제조업에 종사하는 전통적 노동자 비율의 감소와 서비스 및 지식산업에 종사하는 노동자가 증가된 현실을 반영하며, 유럽과 같은 선진 자본주의 국가에서의 적절한 사회적 규제에 의한 산업재해나 물리화학적 요인에 의한 중독사고가 줄어든 현실과도 관련이 있을 것이다. 하지만 한국과 같이 빠르게 산업화를 달성한 국가에서는 아직도 산업재해와 중독사고가 아직도 빈번한 편이고, 또 현재 산업화가 진행되고 있는 개발도상국에서는 산업재해와 화학물질에 의한 중독사건은 아직도 빈발하고 있으며 많은 경우 잘 보고조차 되지 않고 있다. 또 한편 최근의 유럽의 근로환경조사에 의하면 산업화를 먼저 달성하였던 유럽국가에서도 상당한 비율의 사람들이 전통적으로 산업보건에서 관심을 가져왔던 물리적, 화학적, 생물학적, 인간공학적 위해 요인에 노출되는 것으로 조사되고 있다. 이런 사실을 고려했을 때, 근래에 많이 연구되었던 사회심리적 요인 이외에도 물리적, 화학적, 생물학적, 인간공학적 위해 요인과 작업장의 안전까지 포함한 다양한 작업 환경과 연관된 건강 불평등을 연구하는 것이 필요하다고 판단된다.

1장에서는 직업군별 직업적 위해요인의 노출 격차를 분석한 후 직업적 위해요인 노출과 자기평가건강과 직업관련성 손상과의 관련성을 분석하고자 하였다. 분석은 서베이 가중치를 적용하여

직업군 별로 직업적 위해 요인에 노출되는 분율을 구하였고, 서베이 로지스틱 회귀분석을 사용하여 직업적 위해요인 노출과 자기평가 건강과 업무관련 손상과의 관련성을 분석하였다. 분석결과 낮은 사회적 지위의 직업군에서 직업적 위해요인에 더 많이 노출되었고, 같은 직업군에서도 비정규직이 노동자들이 위해 요인에 노출되는 경향을 보였다. 또 한편 물리, 화학, 인간공학, 사회심리적 위해 요인 노출은 좋지 않은 자기평가 건강과 관련성이 확인되었다. 인지된 건강과 안전에 대한 위험과 중량물 취급과 같은 인간공학적 위험요인은 업무관련 손상의 위험을 증가시키는 것으로 조사되었다. 1장에서는 직업적 위해요인 노출이 건강불평등 발생의 한가지 중요한 경로가 될 수도 있음을 확인하였다.

2장에서는 매개분석(mediation analysis)을 통해 육체노동자와 비육체노동자간의 건강격차를 매개하는 요인을 분석하여 건강 불평등의 경로들을 파악하고자 하였다. 인지된 위험하거나 건강에 해로울 수 있는 작업 환경, 재정적 불균형, 낮은 직무통제력, 고용형태(employment status), 52시간 이상의 장시간 노동을 건강격차를 매개하는 변수로 가정하고, 각각의 매개 요인은 서로 독립적이라고 가정한 상태에서 직업의 효과로 설명되는 효과의 크기(natural direct effect), 각각의 매개 요인이 매개되는 효과의 크기(natural indirect effect)와 전체 효과(marginal total effect) 그리고 매개요인로 설명되는 분율(proportion mediated)을 구하였다.
분석 대상은 3차 취업자 근로환경조사의 임금노동자로 한정하였고, 분석은 Stata 사용자개발 프로그램인 “paramed” 와 “medeff” 를 이용하여 분석하였다. 분석결과 한국에서는 비육체노동자와

육체노동자의 건강 격차를 매개하는 요인 중 안전과 건강에 관련한 작업장에서 인지된 위험과(39%) 장시간 노동으로 인한 매개효과의 크기가(28%), 재정불균형(22%), 고용형태(20%),낮은 직무통제력(7%), 낮은 소득(5%)에 비해 더 큰 것으로 조사되었다.

3장에서는 한국과 유럽의 임금 노동자에서의 작업장에서의 안전과 건강의 인지된 위험과 고용상태의 교호작용을 분석하고자 하였다. 분석대상은 한국의 3차 취업자 근로환경 조사와 유럽의 5차 근로환경 조사의 임금 노동자였다. 서베이 로지스틱 회귀분석과 사후추정 조합 명령문을 이용하여 분석을 실시했다. 교호작용은 덧셈 단위 교호작용과 곱셈 단위 교호작용 모두를 분석하였다. 한국의 임금노동자에서는 덧셈단위 교호작용(RERI:1.03;95%CI:0.48−1.58)과 곱셈단위 교호작용(Ratio of ORs:1.36;95%CI:1.11−1.66)이 모두 유의하게 존재하는 것으로 조사되었지만, 하지만 유럽의 임금노동자에서는 작업장에서의 인지된 안전과 건강에 대한 위험의 영향 그 자체가 더 중요했고, 고용형태와의 교호작용은 덧셈단위와 곱셈단위 모두에서 확인되지 않았다.

4 장에서는 한국의 임금근로자에서의 장시간노동과 낮은 직무통제력의 교호작용의 자기평가건강에 관한 영향을 역학자들이 제시한 권고안에 따라 분석하였다. 분석대상은 3 차 취업자 근로환경조사의 임금노동자 였다. 분석은 서베이 로지스틱 회귀분석과 사후추정 조합 명령문을 이용해서 실시했다. 장시간 노동은 그 자체로 부정적인 자기평가건강과 관련성이 존재하였고,

낮은 직무통제력이 동반되었을 경우에는 덧셈 단위 교호작용보다 통계적으로 유의할 정도로 크게 작용하는 것으로 조사되었지만(RERI:0.18;p=0.027), 곱셈단위 교호작용은 유의성을 보일 정도로 크지는 않은 것으로 조사되었다(p=0.061). 장시간 노동을 줄이는 것은, 낮은 직무통제력 하에서 일하는 낮은 사회경제적 지위의 노동자들의 건강문제를 줄일 수 있는 하나의 중요한 중재의 지점이 될 수도 있을 것으로 보인다.

감사의 글

3 차 취업자 근로환경조사의 원자료를 제공해 주신 한국산업안전보건공단(KOSHA)께 감사의 말씀을 전합니다.

주요어: 건강, 불평등, 직업, 고용, 유해요인 노출, 장시간 노동

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